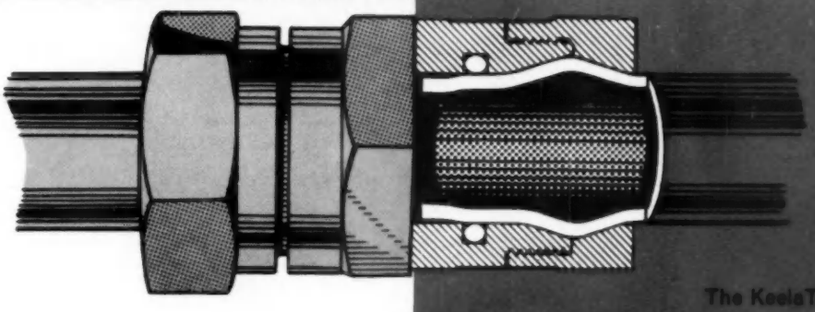
THE ENGINEER

SEPTEMBER 9, 1960 | 28 ESSEX STREET, STRAND, LONDON, W.C.2 | TWO SHILLINGS

KEELAVITE
Hydraulics

HIGH-PRESSURE PIPE COUPLINGS



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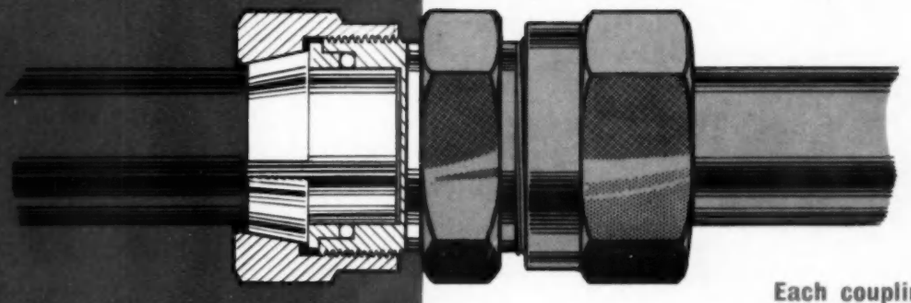

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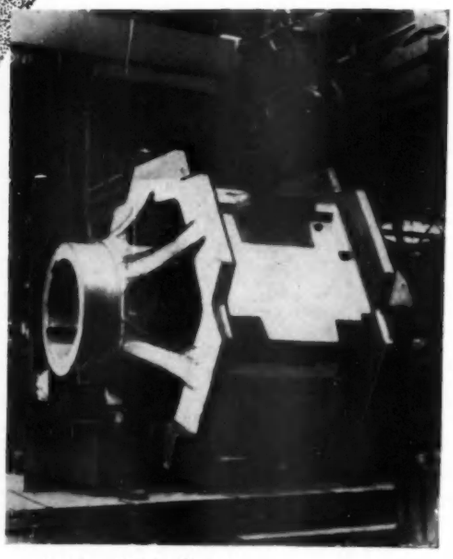

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No. 5459 **SEPTEMBER 9, 1960** VOL. 210

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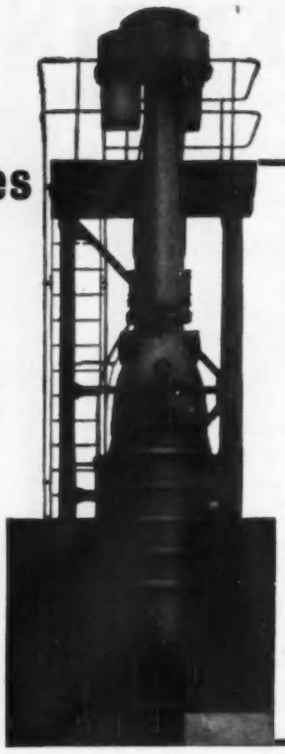
Northampton
relies on Bailey's valves



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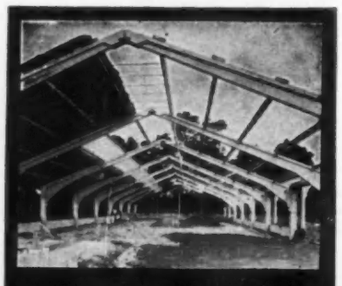

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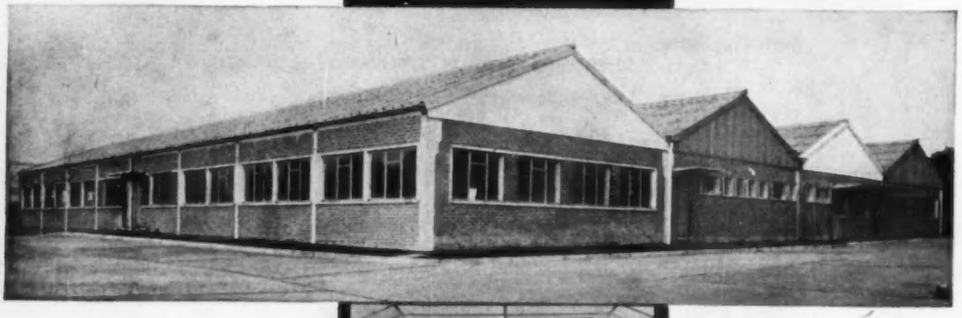

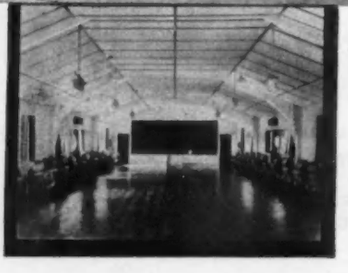

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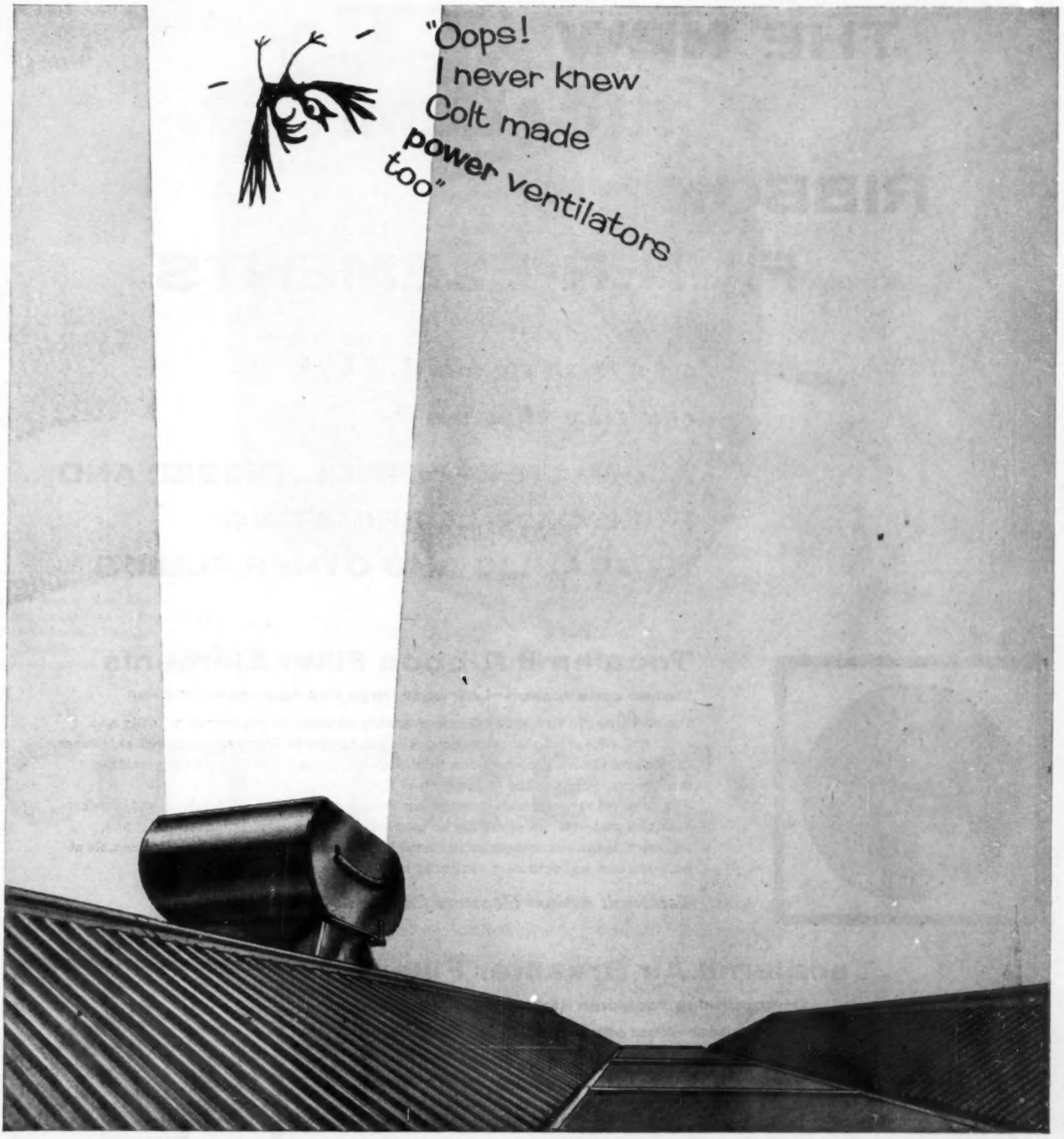

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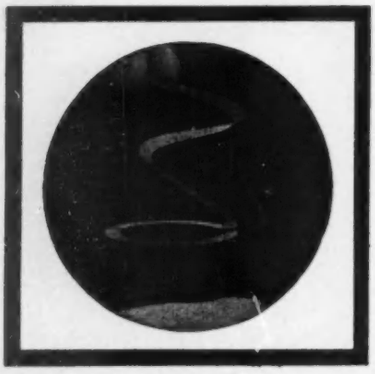

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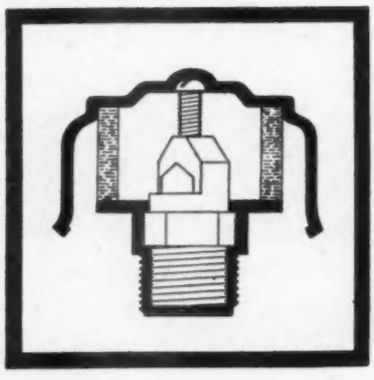

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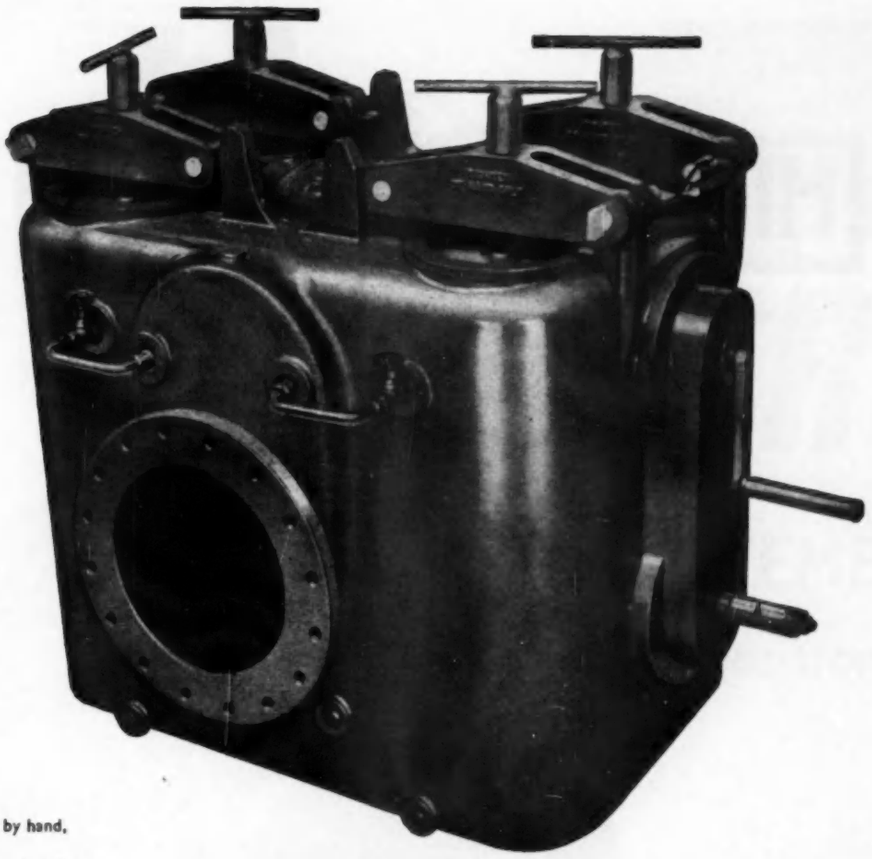

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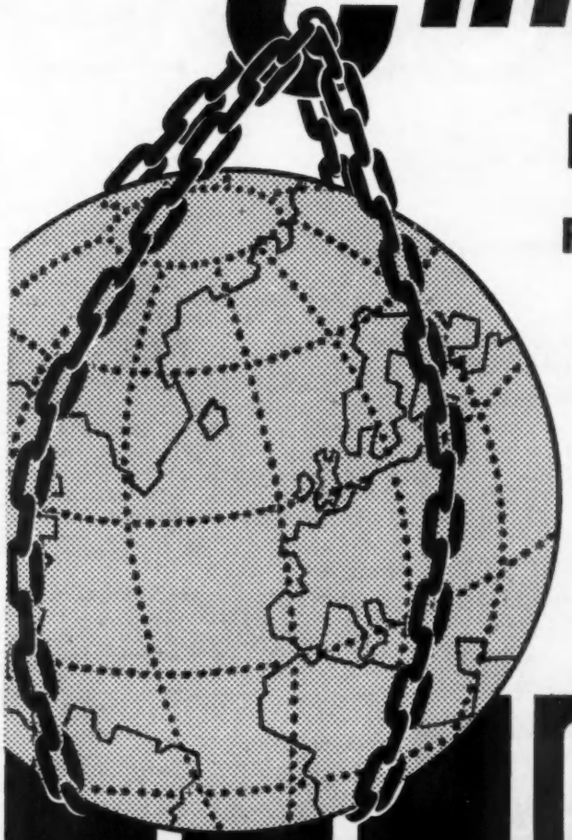

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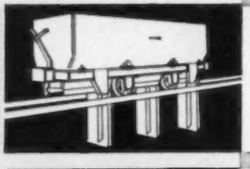

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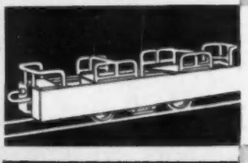

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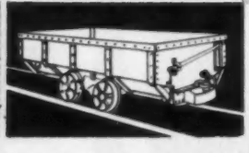

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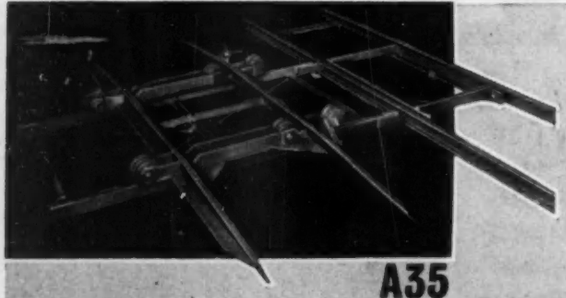

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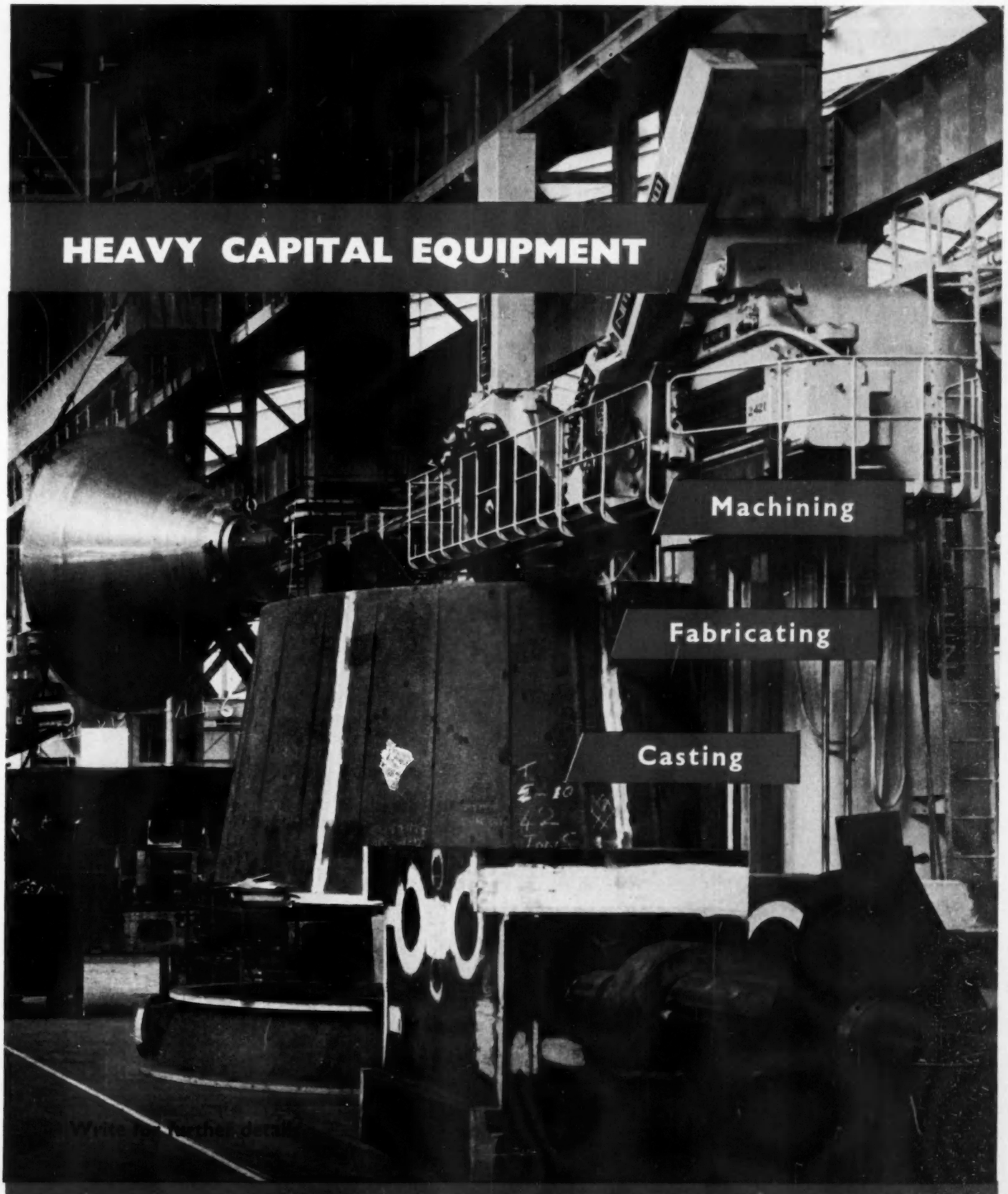

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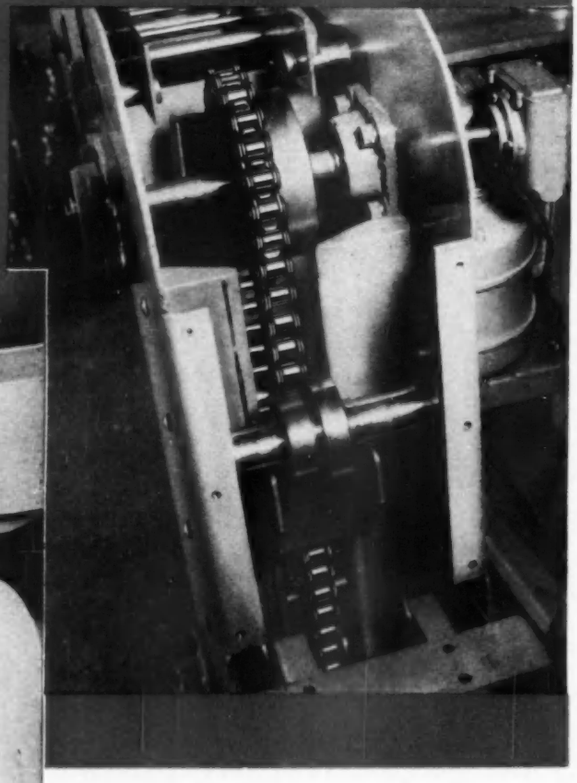

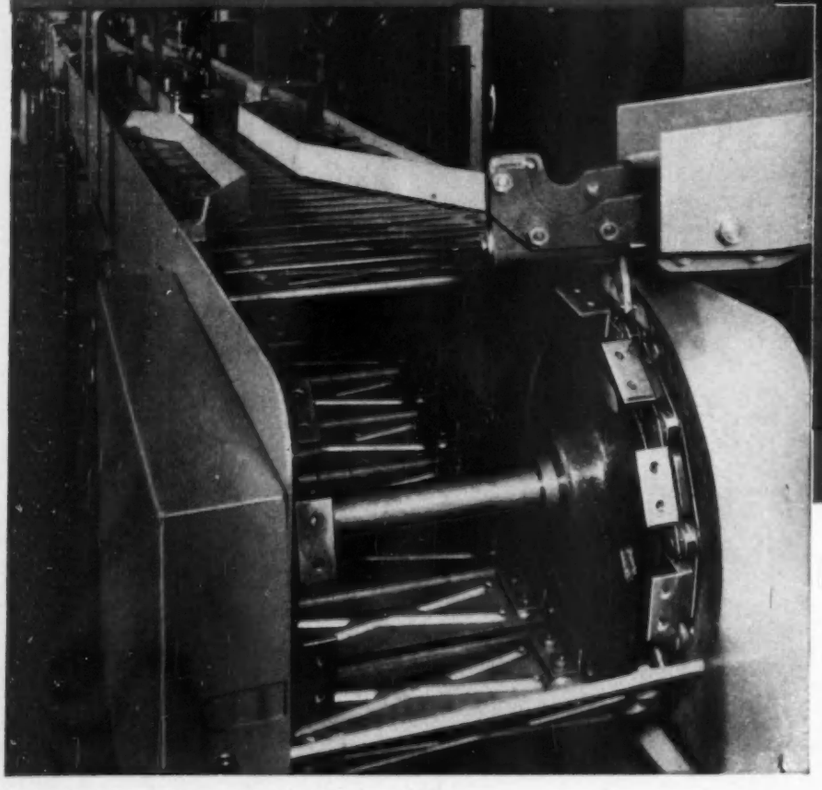

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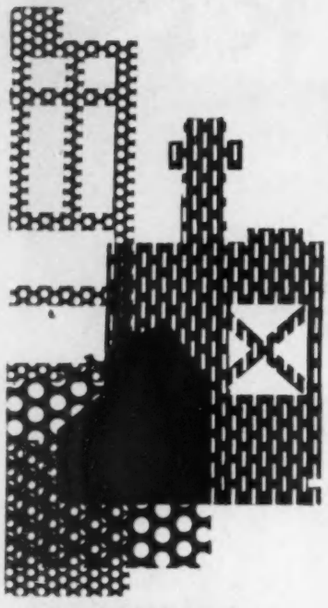

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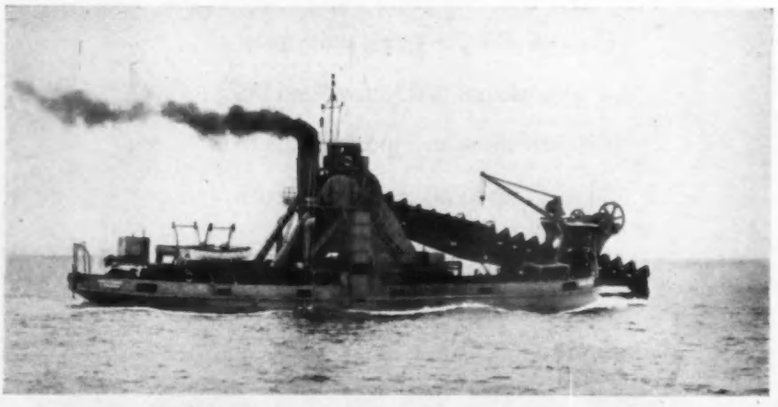

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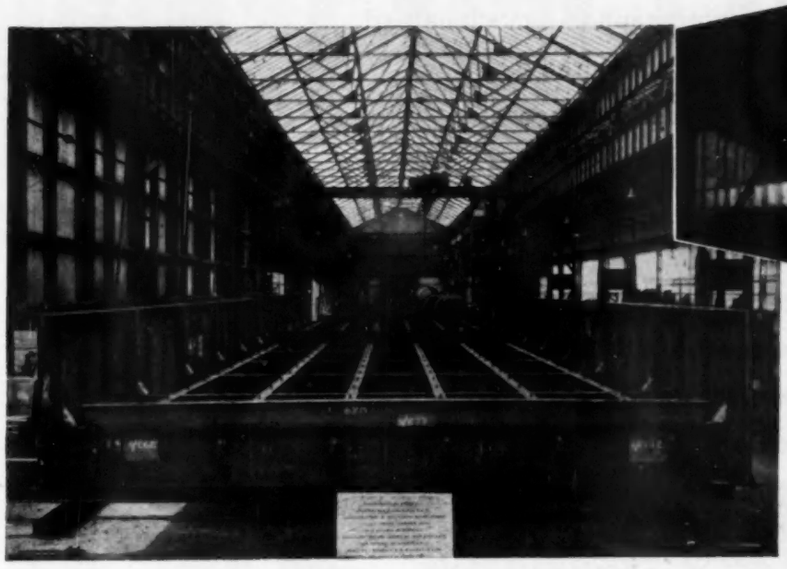

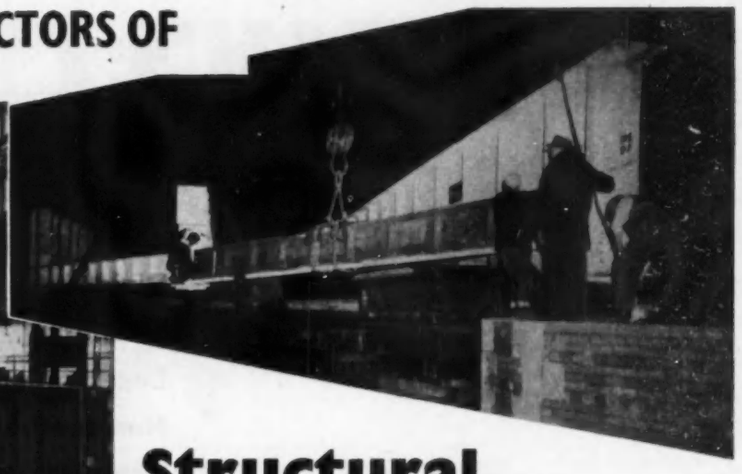

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and the equipment they power, send the coupon to your nearest Ford Dealer or direct to

Please send me technical brochures of your *PETROL/DIESEL Industrial Engines. The maximum B.H.P. required is ..... at ..... R.P.M. Also, please send details of the following equipment powered by your engines.

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in this photograph is a machine part
from which is required a
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combining:
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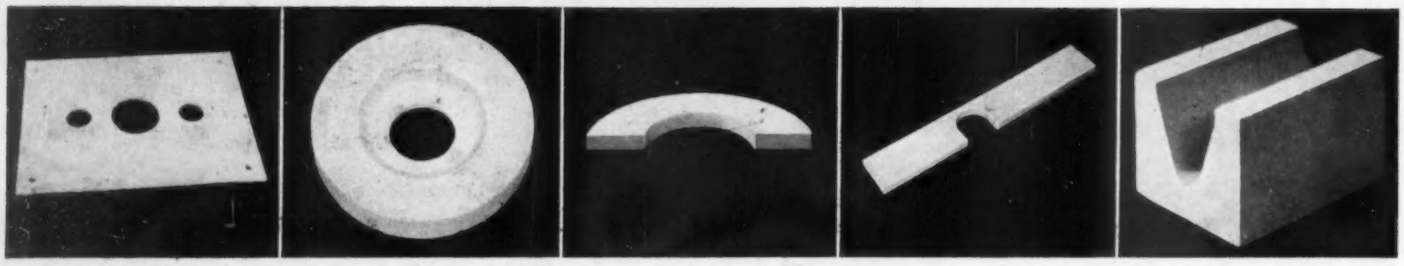
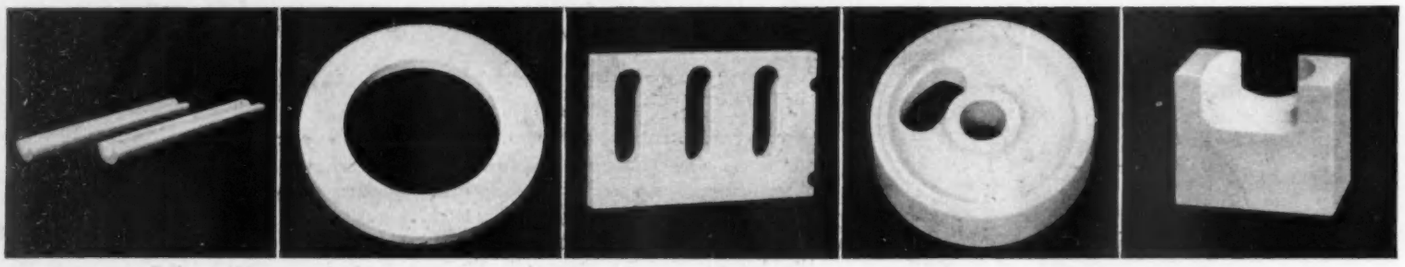


we call them "specials"



Each has been machined in our factory
from flat Marinite sheet (up to 4 ins thick)
to a drawing provided by the user

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STEEL FRAME BUILDINGS
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Factories, Sheds, Mill Buildings, Bungalows, Etc. Etc.,

SPECIALITIES: Pit Headgear, Pumping Stations, Power Stations

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THE TORNADO WAY

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Dirt costs time and money!

For a very reasonable outlay you can protect your staff from dangerous fumes, grit and dust, by using the :

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Laycock Engineering Limited announce that Layrub Flexible Couplings are now available for general industrial use.
As the original designers and producers of this coupling, we shall be pleased to offer full advice for its use in every form of industrial transmission however large—however small.
The Layrub Coupling needs no lubrication and it provides vibrationless, trouble-free, full transmission of power in all conditions.

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INDUSTRY

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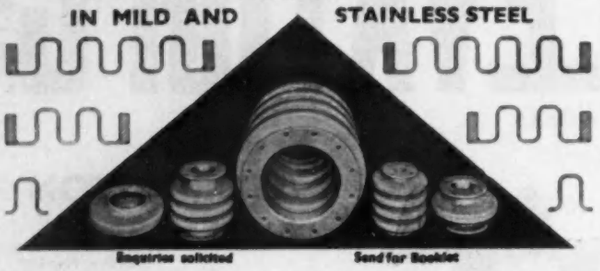
IN MILD AND STAINLESS STEEL



also AIR RECEIVERS, CHIMNEYS, TANKS, PIPE WORK, PRESSURE CYLINDERS, AND FABRICATED STEEL PLATEWORK

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PAXOLIN BEARINGS

a non-metallic bearing suitable for heavy applications

Illustrated here is a large trunnion bearing we have produced for a ball mill. The bearings liners—nearly three feet in diameter—are of Paxolin laminate and fit into cast steel housings.

Paxolin bearing are shock resistant and with water lubrication, or immersed in water, can be used where grit or sand is unavoidable or where occasional but reliable functioning is required. Bore hole pump shafts, rolling mills, rudder and stern shaft bearings are a few examples of the many applications for Paxolin bearings. "Paxolin" serves so many purposes so well.

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"Paxolin" is a registered trade mark.

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KARIBA at 330 kV.

All the bushing porcelains for
the 330 kV. circuit breakers
All the 330 kV. strain insulators
for the substations
and the 330 kV. post insulators
for some of the substations by

BULLERS

MAIN CONTRACTORS · B.T.H. Co. Ltd.
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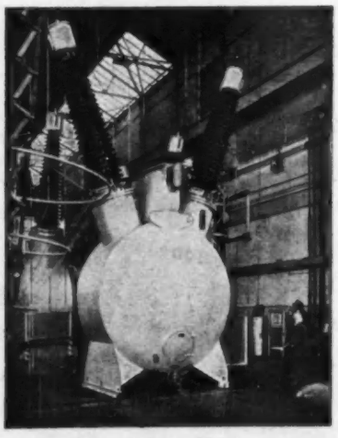

The illustrations show a complete 330 kV. bushing insulator and a 330 kV. circuit breaker, by courtesy of the B.T.H. Co.

BULLERS LIMITED · MILTON · STOKE-ON-TRENT · STAFFS
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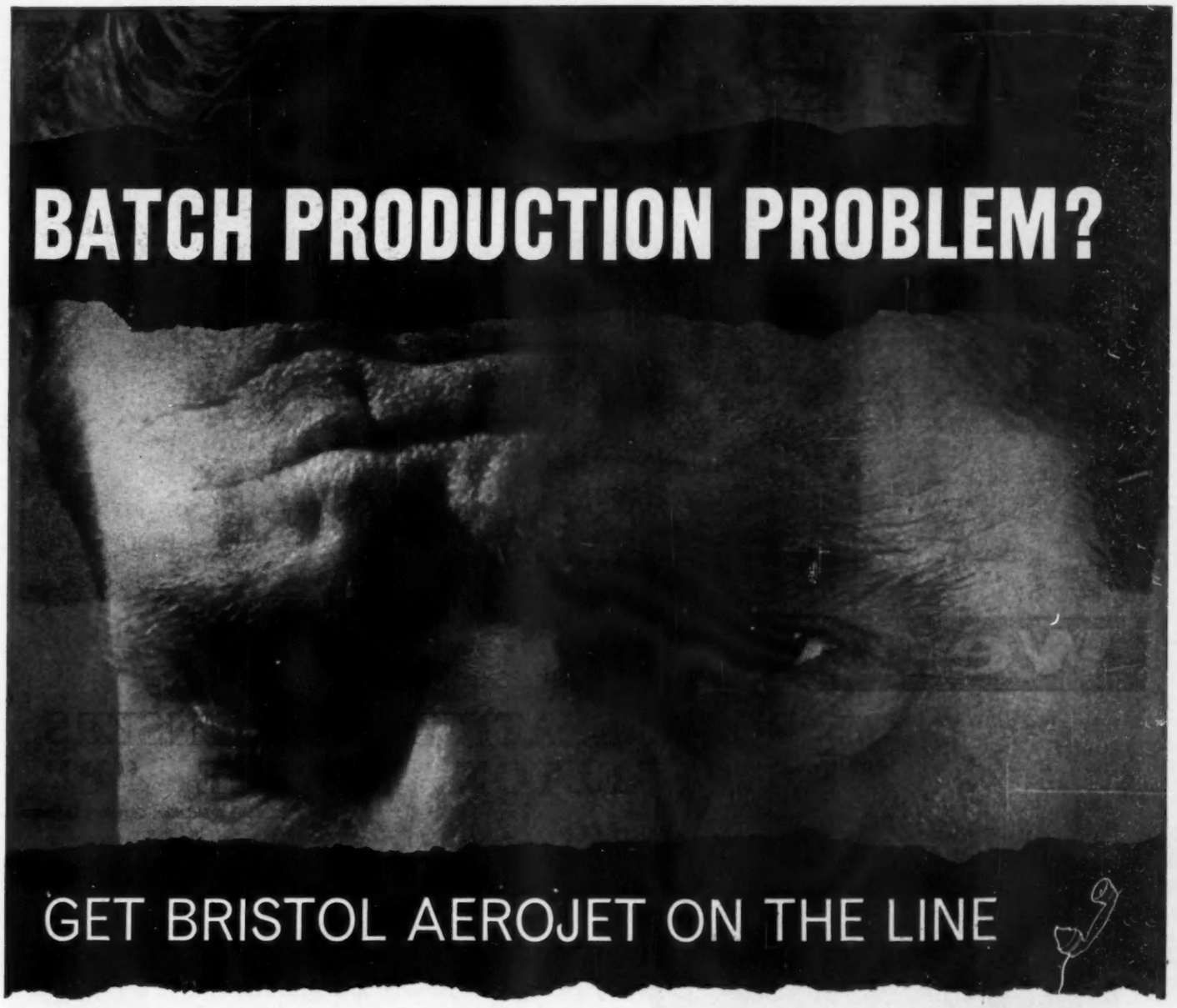

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If you have a batch production problem, we can help. Please telephone or write to:—

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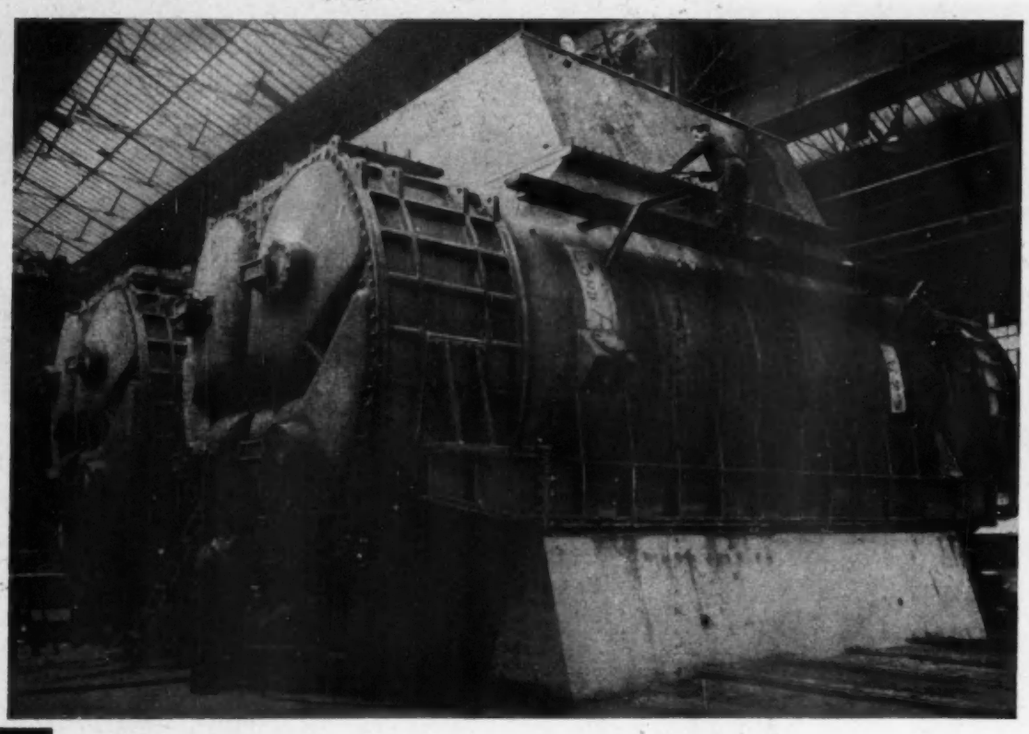
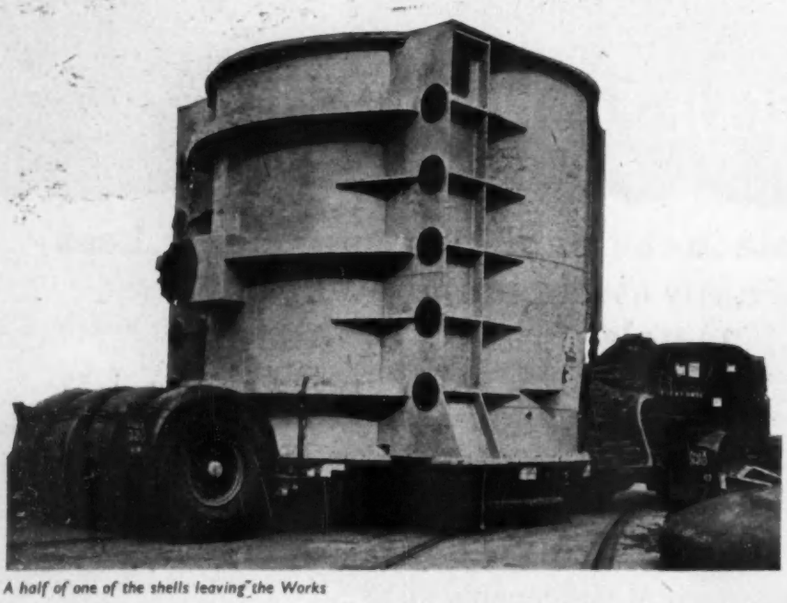


Weir

REGENERATIVE CONDENSERS *for* SKELTON GRANGE "B"

Merz & McLellan, Consulting Engineers



A half of one of the shells leaving the Works

This is the first of four Weir Regenerative Condensers for the 120 MW Turbo-alternators at the C.E.G.B. Skelton Grange "B" Power Station. Each shell is 25 ft. 9 in. long and 14 ft. in diameter, and the total cooling area is 85,000 sq. ft (over 60 miles of tubing!).

Highest Vacuum obtainable under given working conditions.

Condensate delivered at temperature corresponding to the vacuum — minimum temperature drop — highest thermal efficiency.

Condensate thoroughly de-aerated. Any air is efficiently cooled.

Also manufactured under licence for marine service by the leading shipbuilders.

Weir

G. & J. WEIR LTD., CATHCART · GLASGOW S4

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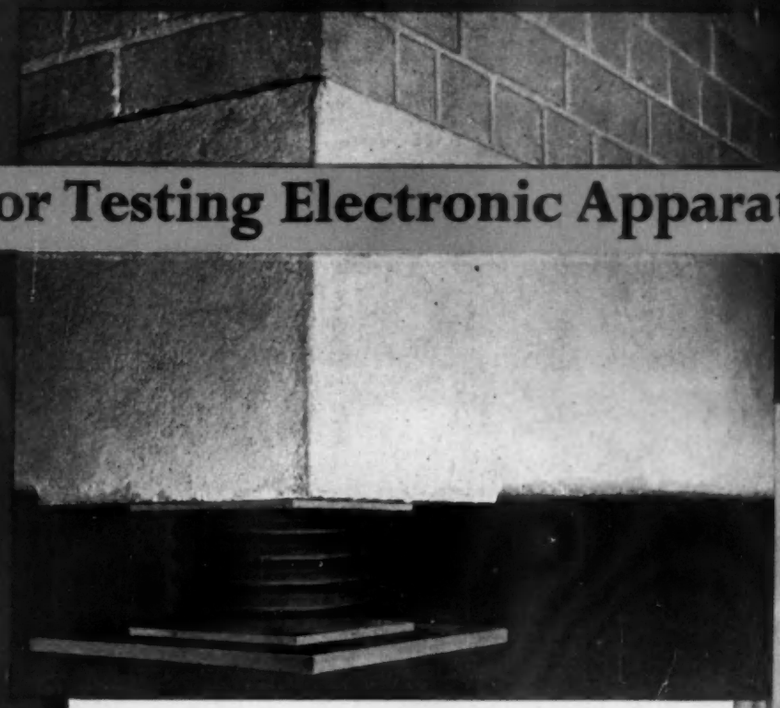
For Testing Electronic Apparatus



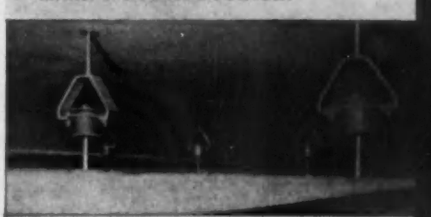
Isolating a 40-ton sound-proof room from ground vibration

Dawe Instruments Ltd., wished to isolate from ground-borne vibration a 40-ton anechoic chamber used for the calibration of sound level meters.

The chamber was mounted on eight Metalastik sandwich type insulators giving a static deflection of 0.25". These are giving excellent insulation against ground-borne vibrations with disturbing frequencies of 1000 cycles per minute and upwards.

In most cases trouble from vibration, or noise due to vibration, is most easily overcome by isolating the disturbance at source. Among the many Metalastik anti-vibration mountings for industrial machinery, lifts and ventilating equipment is the famous "Cushyfoot". A brochure on the application of Cushyfoot mountings to a wide variety of machines is available on request.

Anechoic and Reverberation chambers at the Hemel Hempstead laboratories of the Acoustical Investigation and Research Organisation Ltd.,—independent consultants in Acoustics—are supported on large rubber-bonded-to-metal mountings supplied by Metalastik. Photograph shows interior of the Anechoic chamber.



An acoustic ceiling suspended on "Metacone" anti-vibration mountings which bring the natural frequency of the ceiling below the audible range and thus prevent resonant vibration due to airborne noise. Photograph by courtesy of Werkspoor N.V., Amsterdam.

METALASTIK

METALASTIK LTD., LEICESTER

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D

SWEDISH LADDER

New drifting technique doubles drill-crew output

Controlled feed · guided collaring · mechanical retraction— so one man can operate two rigs

NORTHERN SWEDEN has been the proving ground of a revolutionary rock drilling method which has opened the way to a completely new conception of drill-crew output. Known as the Swedish Ladder Drilling Method, this new technique has been employed on hydro-electric projects at Korsselbränna and Stalon where drilling platforms with 16 rock drills operated by 8-man drill crews have been used.

Atlas Copco drills mounted on retractable pusher legs* are rested in cradles running horizontally in "ladders". Contractors and drill crews have found that these rigs, cheaply and simply constructed, offer the following advantages:

INCREASED PENETRATION—full feed power is ensured by the ideal horizontal feeding position of the pusher leg.

HIGHER OUTPUT PER MAN/HOUR—due to greater penetration and the fact that *one man handles two drills.*

REDUCED CREW FATIGUE—collaring is made simple as operators need not hold the drills. Drill steels are mechanically withdrawn from holes using the retractable pusher leg.

FEWER DRILL STEEL CHANGES—long steels can be used from the start. For greater durability 1″ Sandvik Coromant integral steels are used.

GREATER DRILLING ACCURACY—thanks to the fixed ladder base and pre-positioning of drills for pattern drilling.

DRILLING METHOD

DRAMATIC RESULTS OF LADDER DRILL TESTS

The figures show the dramatic increase in drilling achieved by ladder rigs in a 60 sq.m. tunnel at Stalon driven in hard-drilled quartzite. Gross effect refers to the mean value for the whole drilling period, including collaring, changing steels and the usual routine delays. *Note that the gross effect is exactly doubled.*

GROSS EFFECTS

[redacted]

19.5 metres/man-hour Conventional drilling with one rock drill.

[redacted]

39.0 metres/man-hour Ladder drilling with two drills.

Available from Atlas Copco. The Swedish Ladder Drilling Method was originally introduced by Widmark and Platzer, one of Sweden's leading contracting companies, and has been further developed by them and by the Swedish State Power Board. Specially evolved with Atlas Copco trigger-operated retractable pusher legs*, this method and equipment has been exhaustively tested and proved under tough Swedish drilling conditions. There are Atlas Copco companies or agents in ninety countries and details of the new equipment are readily available from them or from the address below. Wherever you are, the international Atlas Copco group offers expert advice on the selection of equipment and complete after-sales service.

WRITE FOR THE BOOKLET! The Swedish Ladder Drilling Method is described in greater detail in a new Atlas Copco booklet. Write for a copy to your local Atlas Copco company or agent or from the address below.

* Patents pending

Atlas Copco PUTS COMPRESSED AIR TO WORK FOR THE WORLD

ATLAS COPCO AB, STOCKHOLM 1, SWEDEN

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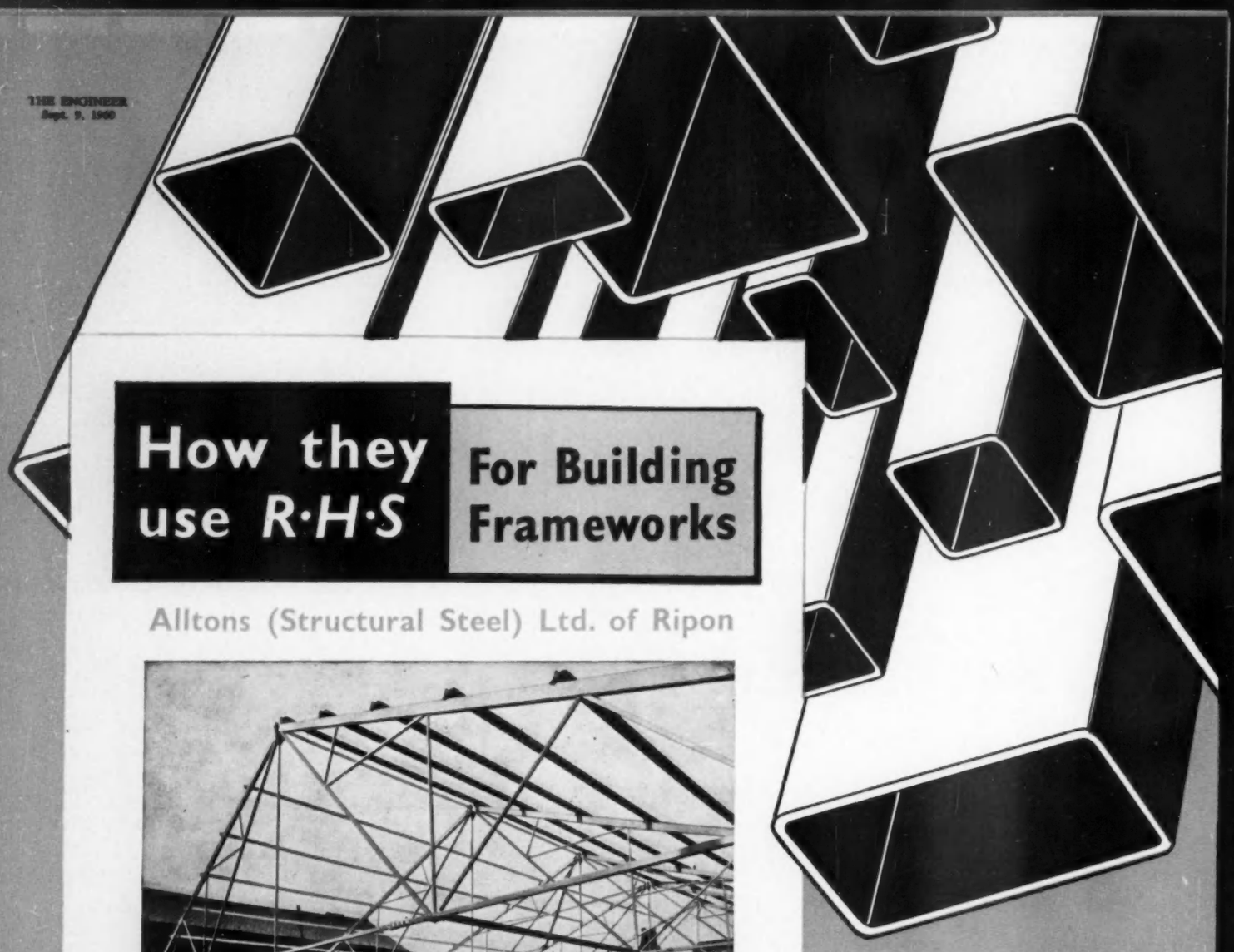
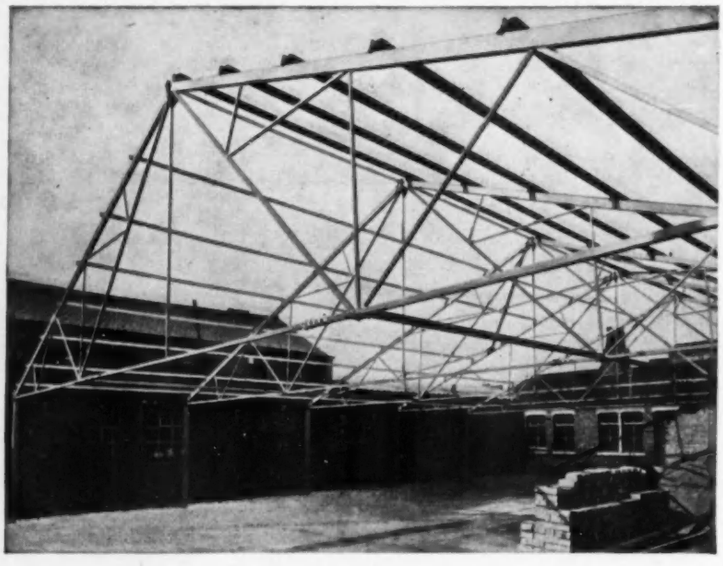


How they use R·H·S For Building Frameworks

Alltons (Structural Steel) Ltd. of Ripon



This single storey 60′ span warehouse was erected for one of our appointed R.H.S. stockists, Macnays Ltd. of Middlesbrough, by Alltons (Structural Steel) Ltd. of Ripon, Yorks. The stanchions and roof trusses were constructed entirely from R.H.S. and designed to comply with the requirements of BS 449:1959.

Rectangular Hollow Sections (R.H.S.) are now being used for a wide range of mechanical and structural purposes. The sizes available in the Stewarts and Lloyds' range of hot-formed sections are listed in the accompanying table. R.H.S. eliminate the need for special shaping of components before welding. Any straight-cut R.H.S. or tube will fit accurately against their flat sides whether square-on or at an angle and, moreover, lugs of various kinds produced from tube or bar are easily attached. Welding is simple and no bevelling is necessary.

Our subsidiary, Tubewrights Ltd., of 25 Buckingham Gate, London, S.W.1, is willing to advise on or quote for any welded sub-assemblies.

STEWARTS AND LLOYDS WAREHOUSES THROUGHOUT THE COUNTRY STOCK R.H.S.

Pamphlet giving full dimensions, properties and prices will be sent on application to:—

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STRUCTURAL STEEL DEPARTMENT, BROAD STREET CHAMBERS, BIRMINGHAM 1

Telephone: Midland 2700. Telex: 33333

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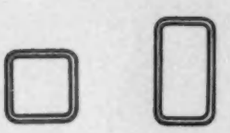

FROM	FROM
1″x 1″	1⅞″x ¹³⁄₁₆″
TO	TO
5″x 5″	6″x 4″

R.H.S. ARE PRODUCED TO THE PHYSICAL PROPERTIES OF B.S. 1775 GRADE 16

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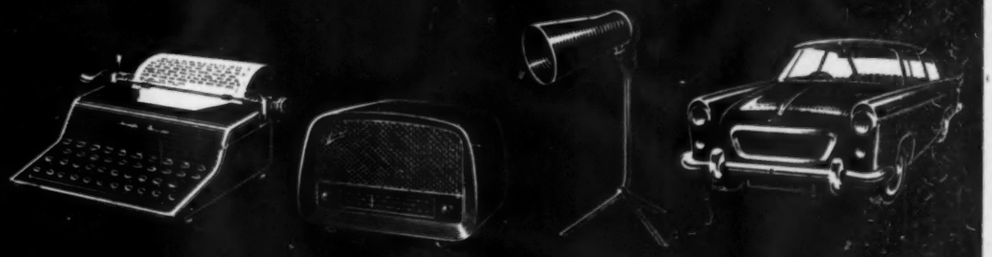
BEAUTY

Plastic Coated Steel Strip has numerous possible applications and for this reason is being produced in a wide range of textures and colours. Write for further details.



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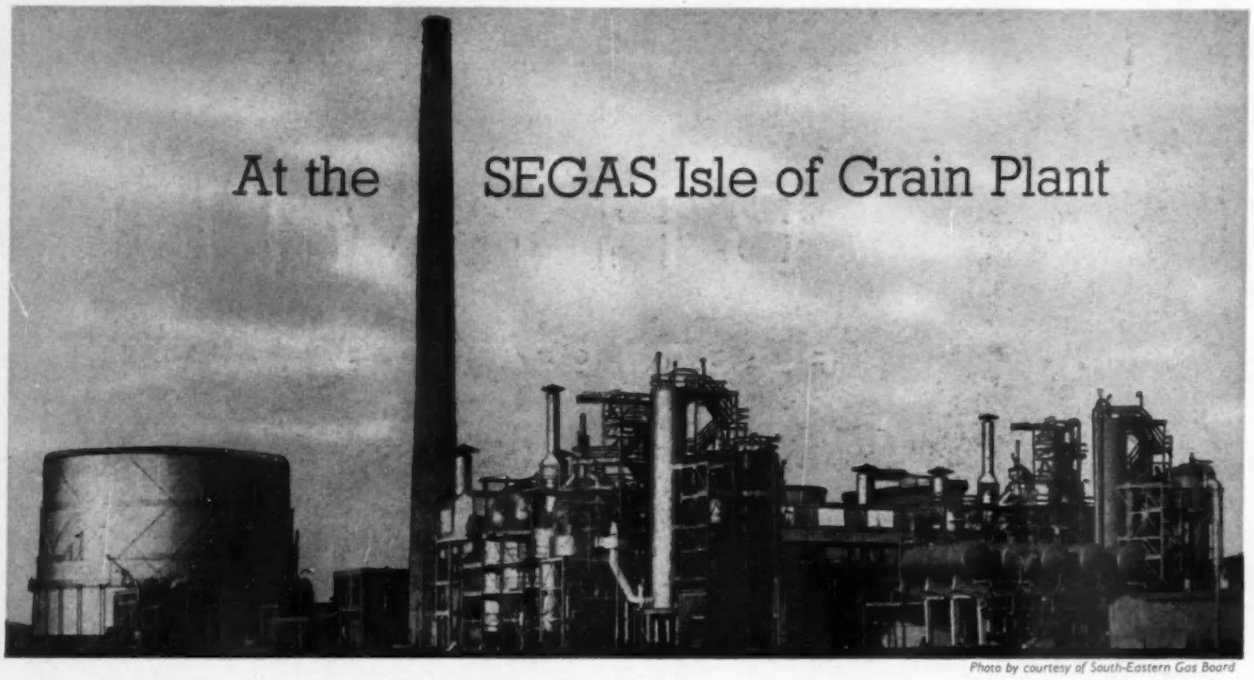
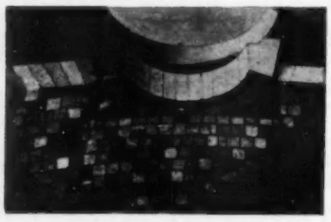


Photo by courtesy of South-Eastern Gas Board

R.B.HILTON installed the refractory linings

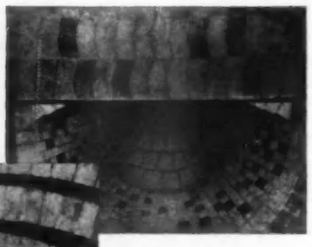


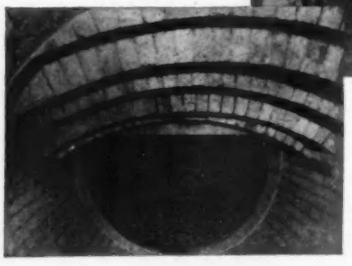
Access hole blocks

Gas from oil at the new Segas Isle of Grain plant is the latest development in British fuel production. A high standard of refractory brickwork is called for in the lining of these ducts and the installation of the arches and domes. Both workmanship and materials must be of the highest quality.

R. B. Hilton Limited carried out the work using materials supplied by General Refractories Ltd. A team of experienced craftsmen worked under the supervision of the Area Manager and the personal scrutiny of one of the company's directors.

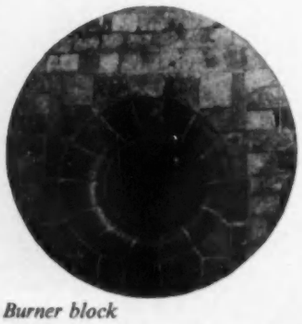
Further details of Hilton's services will gladly be provided on request.





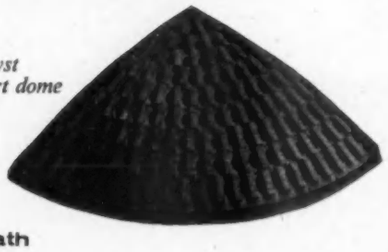
"V" Block Arch blocks

Stepped arches



Burner block

Catalyst support dome



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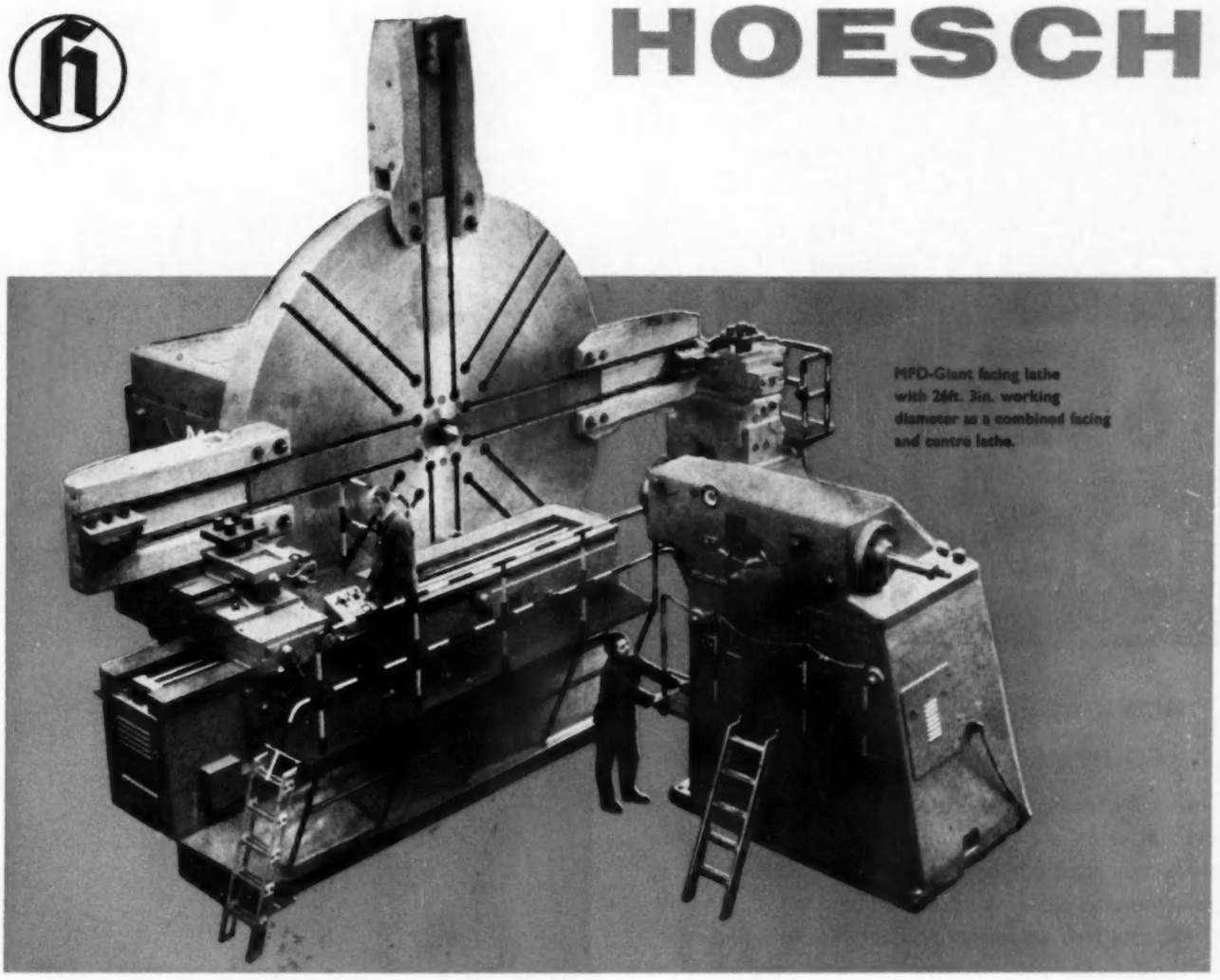

MFD-Giant facing lathe with 26ft. 3in. working diameter as a combined facing and centre lathe.

The manufacturing programme of Hoesch AG. runs from coal via steel right through to the finished product. One of the Members of the Hoesch combine is Maschinenfabrik Deutschland AG Dortmund. Their production programme comprises:

HEAVY MACHINE TOOLS: Centre Lathes . Facing Lathes . Roll Turning Lathes . Slotters . Shapers . Rail and Section Bending Machines . Wagon and Locomotive Wheel Set Turning Lathes . Hydraulic Wheel Set Presses . Axle Journal Polishing or Burnishing Machines . Spring Eye Rolling Machines, Spring Winding Machines, Hydraulic Spring Bundling Press for Car and Wagon Springs.

GENERAL MECHANICAL ENGINEERING: Hoisting Equipment: Travelling Cranes, Grab Cranes, Metallurgical Cranes, Gantry Cranes, Slewing Cranes, Loading Bridges, Coaling Installations. Turn Tables for Locomotives and Wagons. Travelling Platforms sunk and level. Axle Changing Jacks. Locomotive and Wagon Lifting Jacks. Compressed Air Hydraulic track lifting device D.B.P. (Deutschlandgeraet). Coke Oven Plant Machines: Coke Pusher Machines, Coke Oven Lorry Cars, Coke Cake Guide Cars, Coke Quenching Cars. Pig Iron Ladle Buggies, Slag Ladle Buggies.

SWITCH MANUFACTURE: Switches and Points of every type made of Vignol Rails Preussen V and heavier, in gauges from 900 mm. and up. Switches and Points made of grooved rails Phoenix 37. Curved rails "Deutschland", Double-Curve Points and Curve Points for track curves down to 35 m. semi-diameter. Brake Frogs, Rail Brakes, Dilatations, Buffers.

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Hoesch AG Walzwerke Hohenlimburg: Bright and Alloy Steel in Sections and Merchant Bars.

Trierer Walzwerk AG Wuppertal-Langerfeld: PLATAL — Plastic Coated Steel Strip and Cold Rolled Steel Strip plain, coated and clad.

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NEW GAS-SHIELDED BARE-WIRE EQUIPMENT FOR MILD STEEL*

The revolutionary ST.2 arc welding torch is new, it's sleek, efficient, and a pleasure to handle. The ST.2 is the production man's short cut to greater efficiency and lower welding costs. With this tool and the well-known LYNX wire feed equipment *you can now weld mild steel semi-automatically—*

- **IN ANY POSITION**—flat, inclined, vertical (up or down), and overhead.
- **DOWN TO 20 SWG. SHEET**—and for thick plate as well. (Wide gaps can be tolerated.)
- **FOUR TIMES AS FAST**—on thin sheet compared with other methods.
- **ECONOMICALLY**—high welding speeds—fine wire on large spools—inexpensive gas shielding—all add up to big cost reductions.
- **WITH MINIMUM DISTORTION**—and easily controlled penetration.
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TURNERS "POLY-V" DRIVES SAVE SPACE, TIME, MONEY AND TRANSMITS MORE POWER

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NO BELT MATCHING PROBLEMS • FEWER BELT CROSS-SECTIONS • MORE POWER IN THE SAME SPACE • HIGHER SPEED RATIOS • THE SAME H.P. WITH LESS PULLEY WIDTH.

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For 40 H.P. Drives upwards "POLY-V" "M" section is recommended
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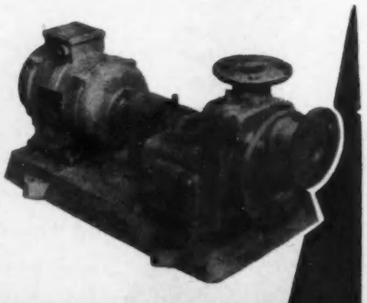

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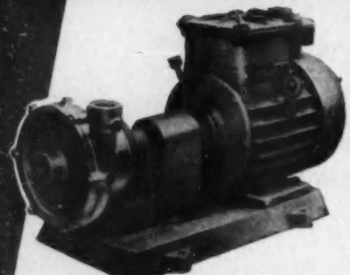
FOR CORROSIVE LIQUIDS ACIDS CHEMICAL SOLUTIONS



1" centrifugal pump fitted with mechanical seal and coupled to flame proof motor. Other types available where gland packing is specified. Pump sizes; up to 1½" screwed BSPT, and 2" flanged BSS'D'

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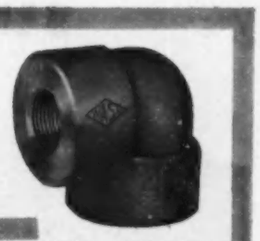

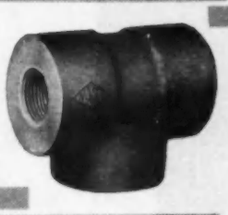

C.W.P. non-shock
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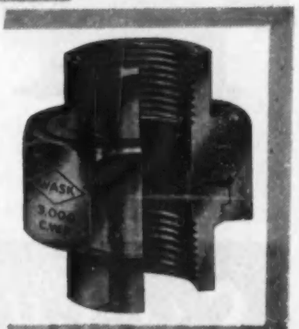

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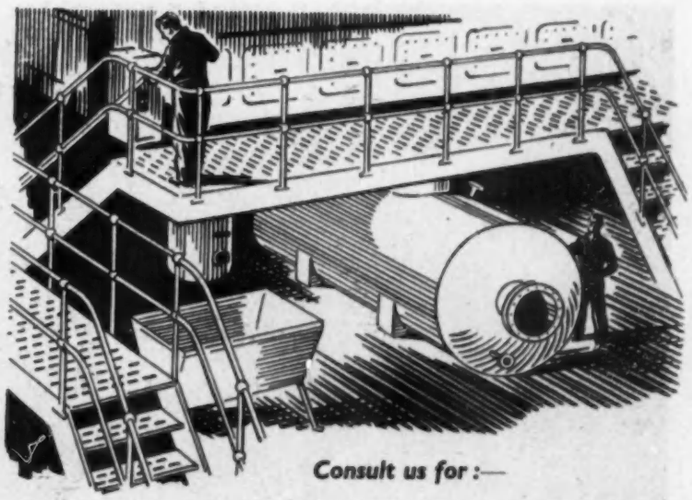

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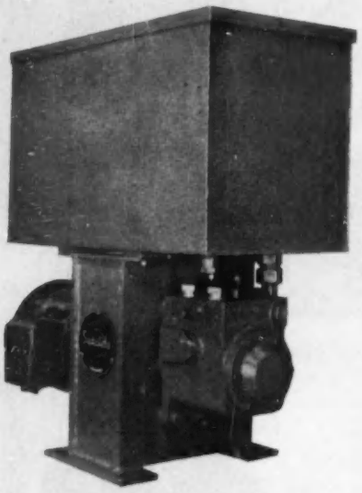
. . . fixed capacity or infinitely variable flow from zero to maximum capacity



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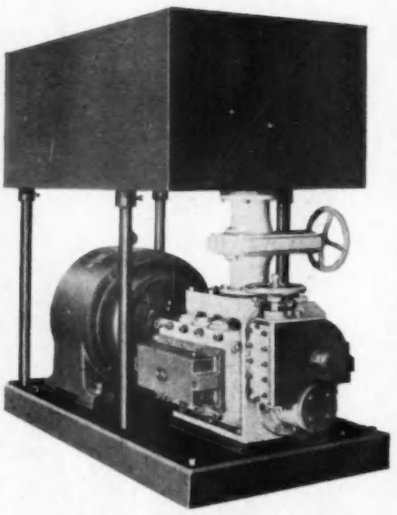
Control of variable flow may be either Manual, Mechanical or Automatic. The pumps may be supplied as separate units or in power pack form.

We shall be pleased to discuss the design and manufacture of pumps to meet your specific requirements.



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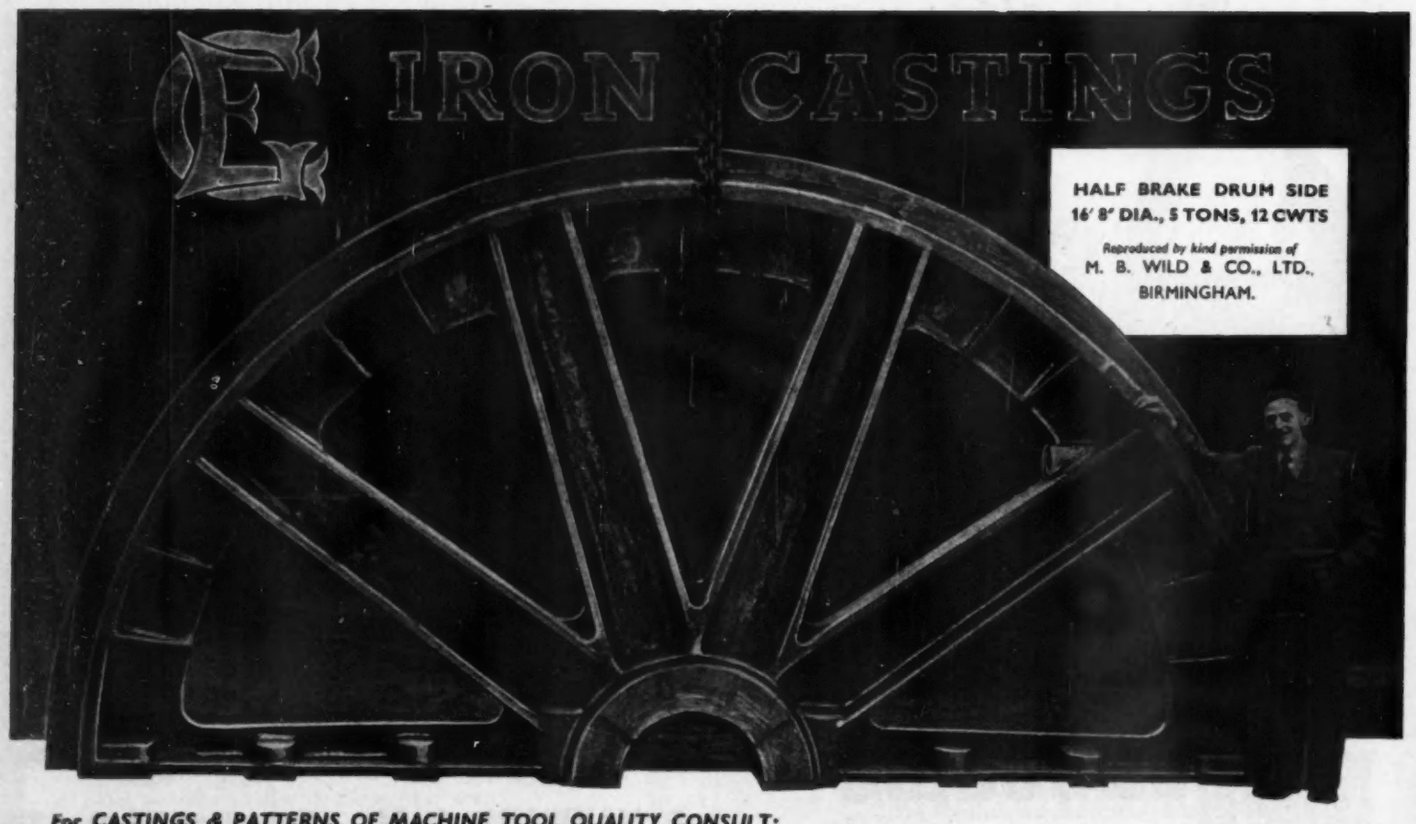

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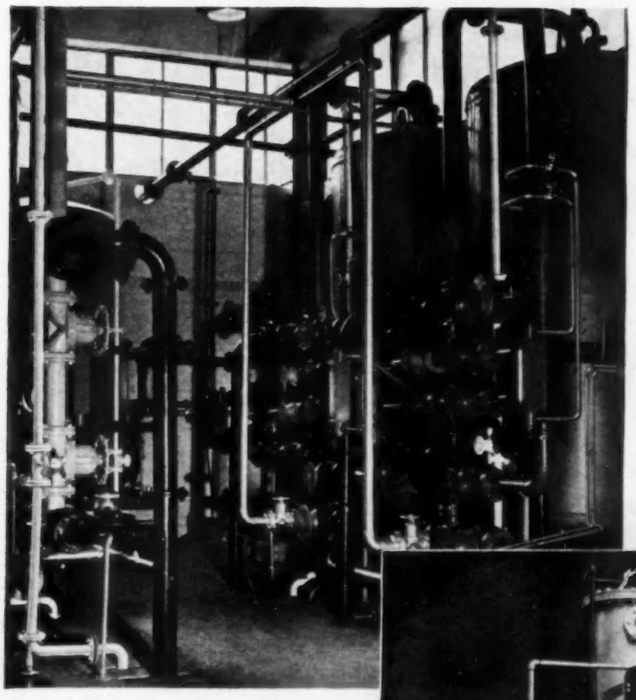

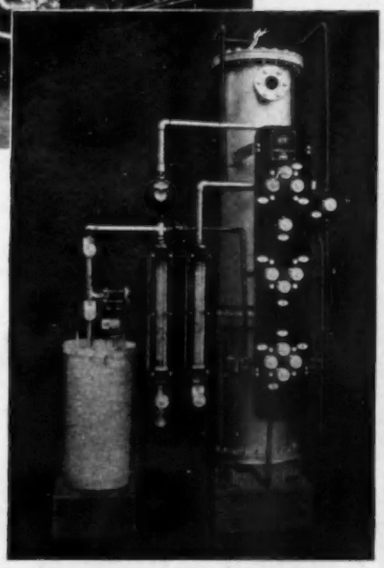

above
Demineralisation plant installed in a synthetic fibre factory. Capacity 11,400 gallons per hour.

on right
Small demineralisation plant, capacity 200 gallons per hour, installed in a research laboratory.

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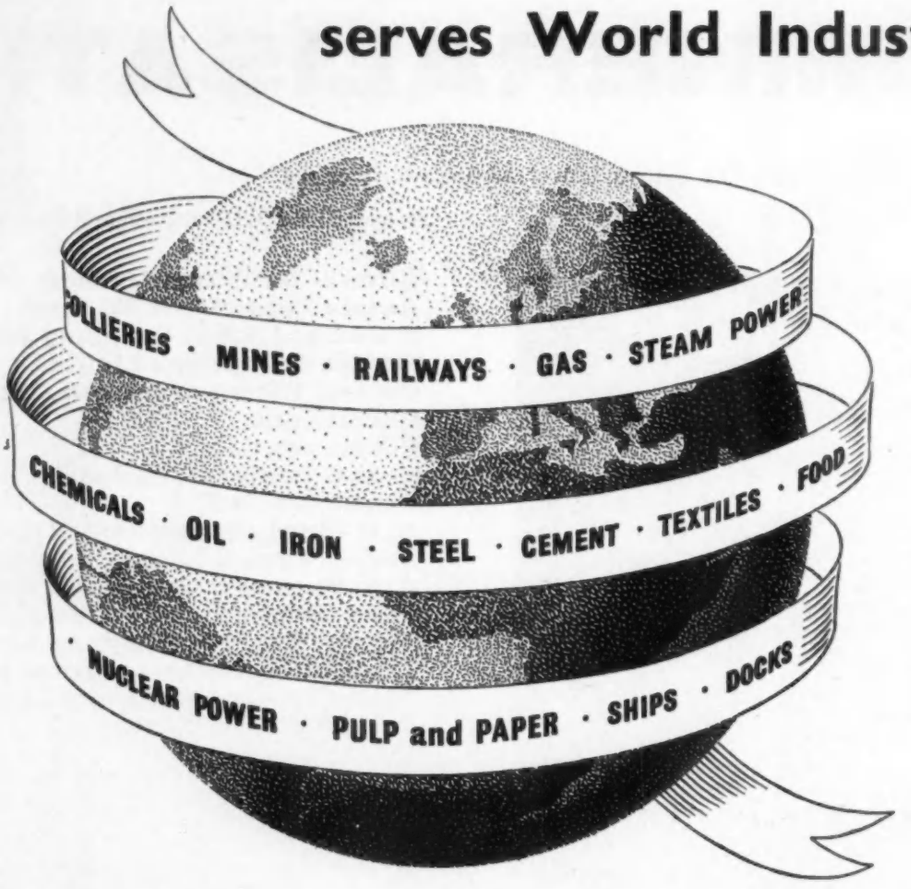
Fluidrive

serves World Industry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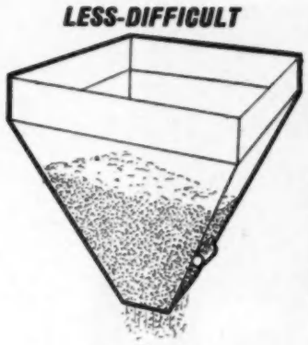
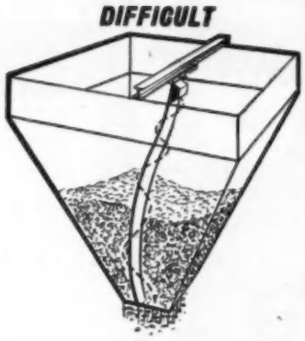
LESS-DIFFICULT



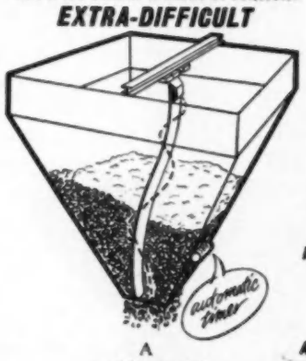
The installation of an external vibrator to a steel hopper.

DIFFICULT



The vibrating reed for application where external vibration is impractical due to structural or other difficulties and if the bunker is made of concrete.

EXTRA-DIFFICULT



A combination of internal and external bunker vibration. Where the external vibrator is timed for 'on and off', the vibration frequency, on slowing down, goes through the natural resonance of the bunker, irrespective of load material contained.

trouble-free bunker discharge

The primitive, inefficient method commonly used for clearing material which sticks in a storage bunker is by applying a sledge hammer to the side of the hopper. This is a form of low frequency, uncontrolled vibration. When vibration is applied at the *correct* frequency, the *correct* amplitude and the *correct* point of application, almost any material can be satisfactorily discharged.

SINEX has the experience with a wide variety of materials and a wide range of hopper designs to recommend how vibration should be applied effectively to solve *your* particular problem.

The three examples illustrated show three different combinations which are typical of many applications, but even these, whilst using the same type of unit, can only be effective if the types of unit themselves are placed in the correct position and have the correct frequencies and amplitudes of vibration to suit the characteristics of the material to be discharged.

It would pay you, therefore, to make use of our experience and to consult us on your particular problem. Send for relevant details and information sheet.

These are some of the many materials which we have handled satisfactorily and ensure trouble-free bunker discharge: Pulverized and small coal, iron-ore, coke, lime, flour, grain, grist, foundry sand, soda ash, cullet, sand, gravel, granite chips and all road stone materials.

Sinex

Bunker clearance Equipment

SINEX ENGINEERING COMPANY LIMITED.

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Tel: Feltham 5081 (5 lines) *Telegrams: Sinexvibro Feltham.*
ASSOCIATED COMPANIES IN PARIS, BRUSSELS AND ZURICH

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In addition to our standard ranges, we design and manufacture special axles and undergear equipment for all types of work. No load is too heavy, too big or too awkward.

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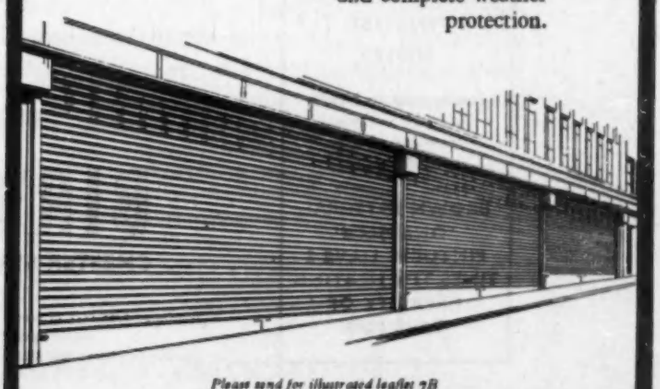
by the makers of Kinylon and Kinrod Grilles

solve the problem

of wide entrances and a sloping road. The bottom rails on these Kinnear Shutters are shaped to accommodate the rise of the road, to ensure good closure and complete weather protection.



Please send for illustrated leaflet 78

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Telephone: Popesgrove 2276. *Birmingham:* Highbury 2804.
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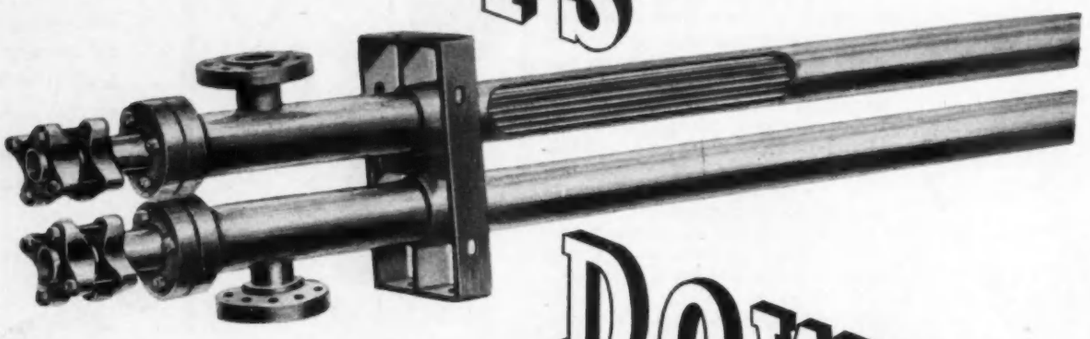

Specialisation in heat exchange problems has enabled us to achieve a number of important results—not least of which is an appreciable reduction in the cost of both heat exchange equipment and operation.
Brown Fintube Double Pipe Heat Exchangers have cut heat exchange costs in three important ways :

★ *Ever increasing sales have CUT FIRST COSTS by making improved production methods possible.*

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With Brown Fintube sectional heat exchangers, existing units can be regrouped to cater for changes in plant process requirements AT ALMOST NO COST. As actual makers of BROWN FINTUBES, we can offer you the best terms and finest service. If you have a heat exchange problem we will give you the answer. And remember—when we DESIGN something we GUARANTEE performance.

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Equally easy to handle but will withstand pressures of over 10,000 p.s.i.

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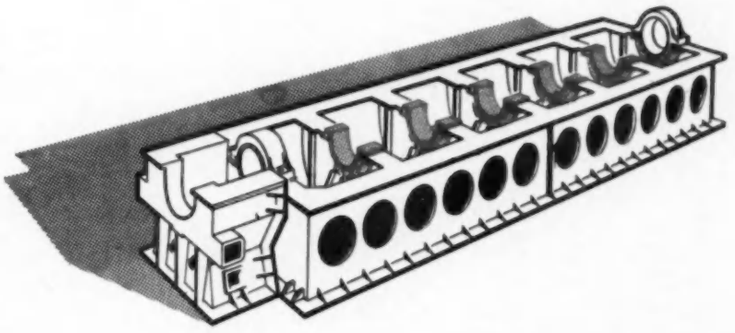

15% reduction in cost

and improved design

This cast steel bearing saddle for the Scott-Doxford Marine engine replaces a more expensive forged block. Freedom of design in steel castings and modern fabricast techniques enabled it to be made to meet functional requirements to an extent not possible by any other method.

Meet your problems in the most economical way. Take advantage of steel foundry know-how and call in a steel foundry engineer at the design stage.

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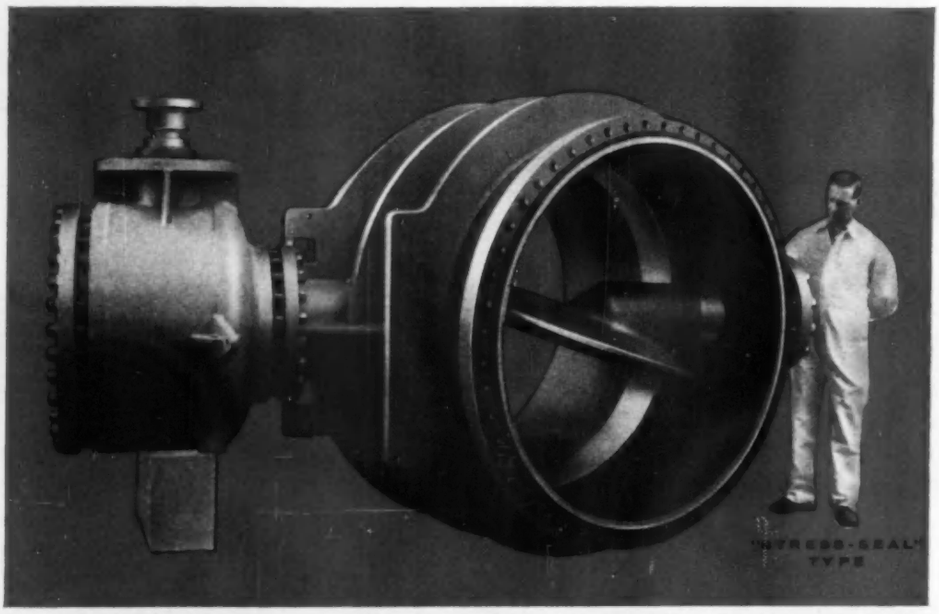

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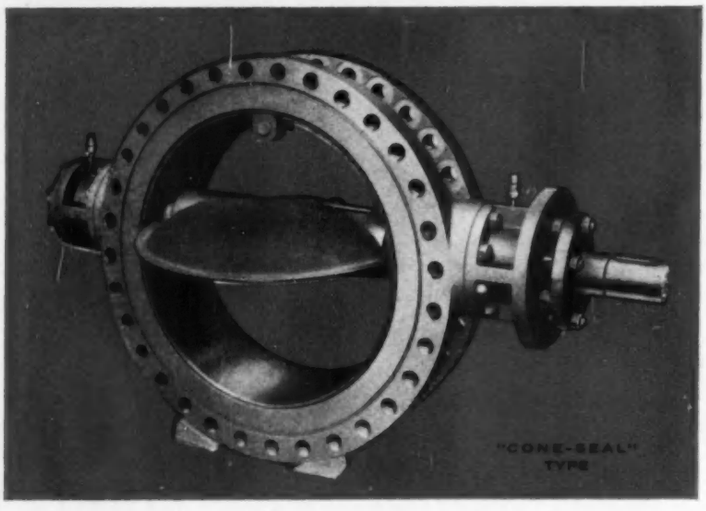

Specially developed for high temperature gas duct service, Blakeborough "Cone-Seal" and "Stress-Seal" Butterfly valves have aroused particular interest in the nuclear field. The "Cone-Seal" construction is applicable to sizes up to 42 in. bore; the "Stress-Seal" from 36 in. upwards. Both give tight closure, or shut-off to very fine leakage tolerances, even under severe thermal shock conditions. They are being supplied for main duct isolating duty on the following power reactors :-

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WINDSCALE	(AGR). "Cone-Seal" type. Eight 24 in. bore. Design conditions : 300 psig. and 1067° F.
	Also: Throttle type butterfly valves (without shut-off), as at present in hand for
TRAWSFYNYDD	Twelve 66 in. bore. Main gas duct throttle service. Twelve 42 in bore. By-pass service.

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J. BLAKEBOROUGH & SONS LTD BRIGHOUSE ENGLAND

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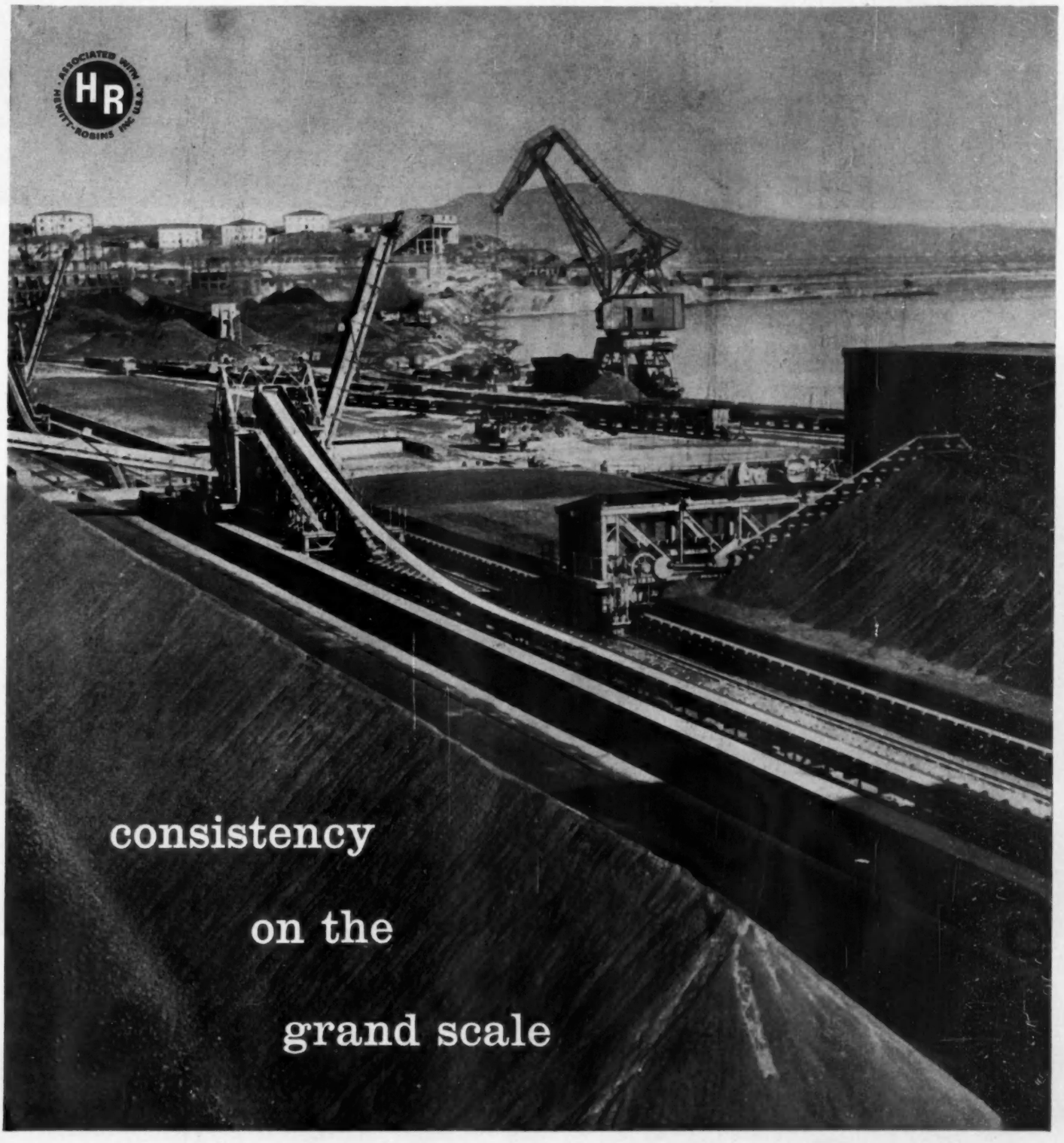

Blast furnaces depend on it. Metallurgists count on it . . . Ores must be blended precisely, and fed with unvarying consistency to the blast furnace . . . That is the reason why Robins-Messiter blending plant was installed in Italy.

Rely on the experience of G.E.C.

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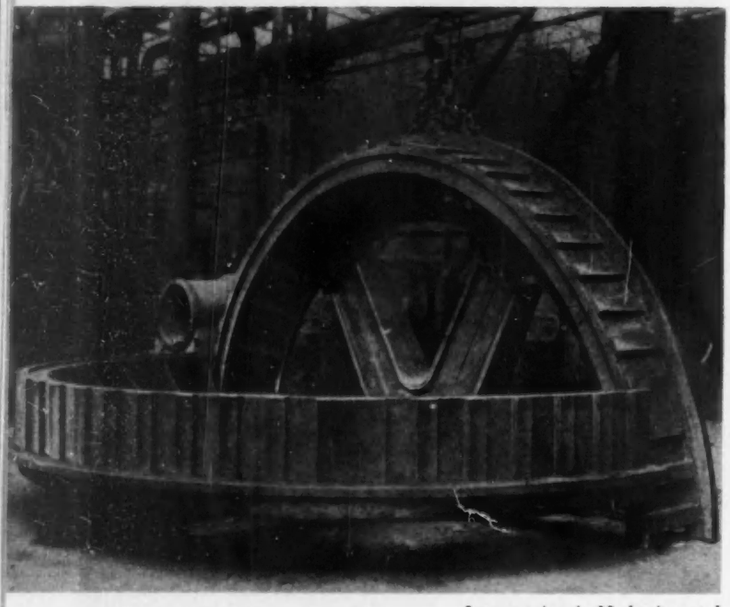
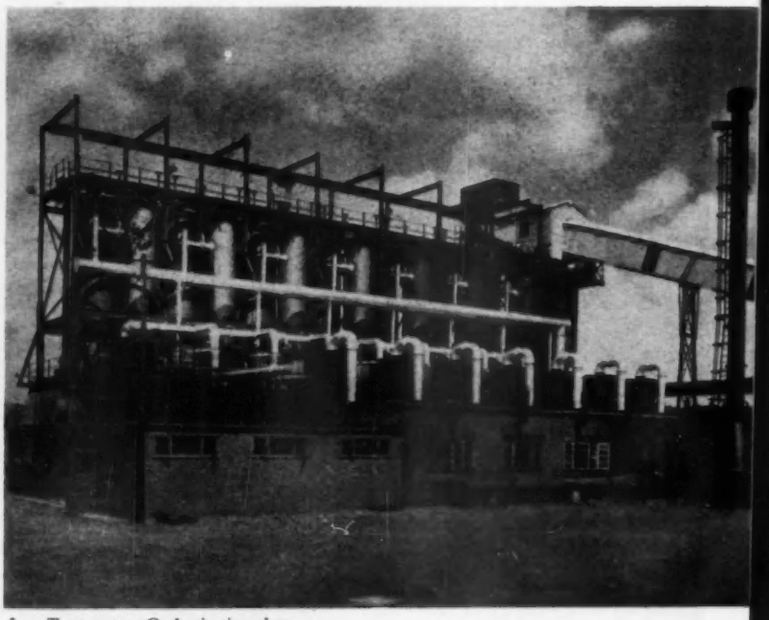
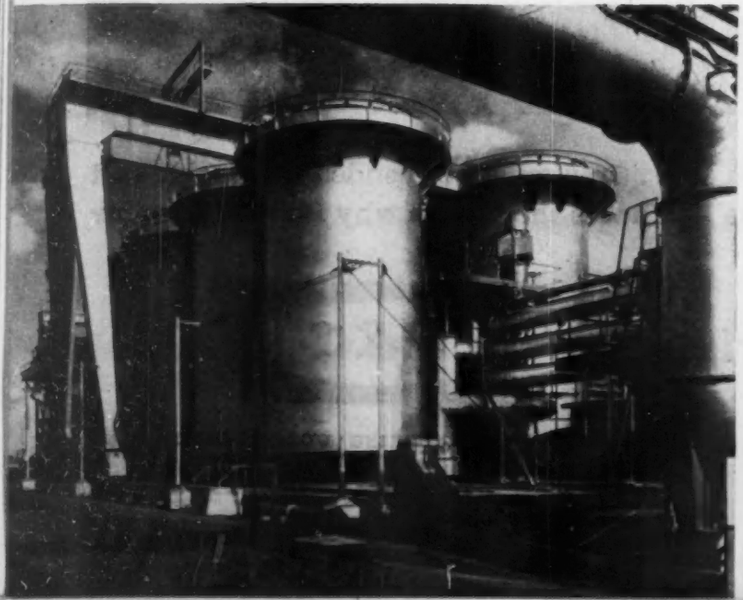


Large castings in Meehanite metal

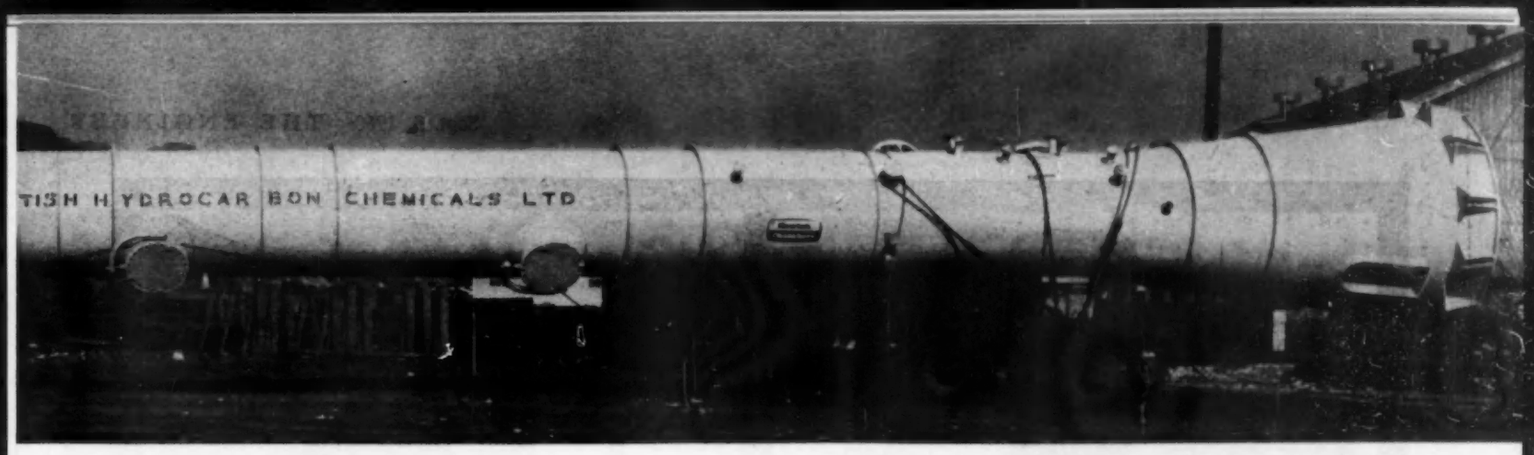


Low Temperature Carbonisation plant.

Tower purifiers with patented mechanical oxide discharger



Inka air preheater



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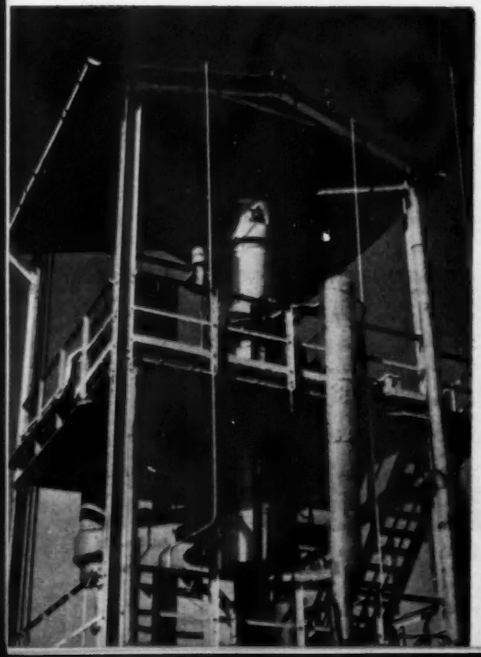
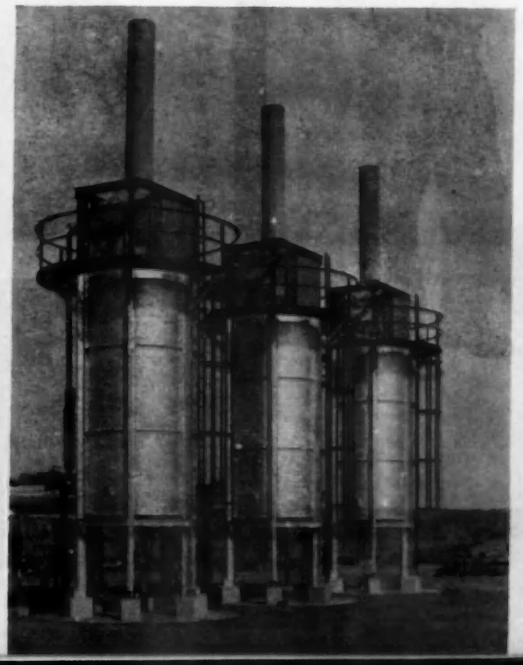
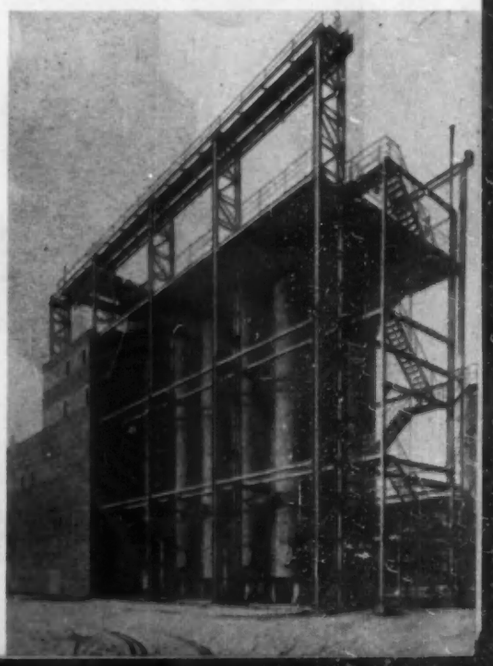
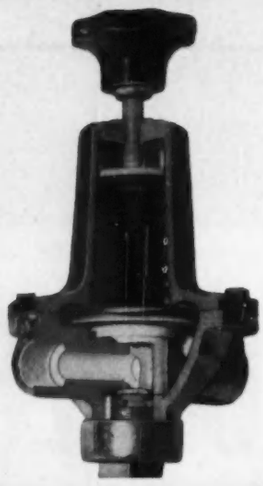


Struthers Wells direct-fired heaters



High pressure gas purification plant to Bischoff designs





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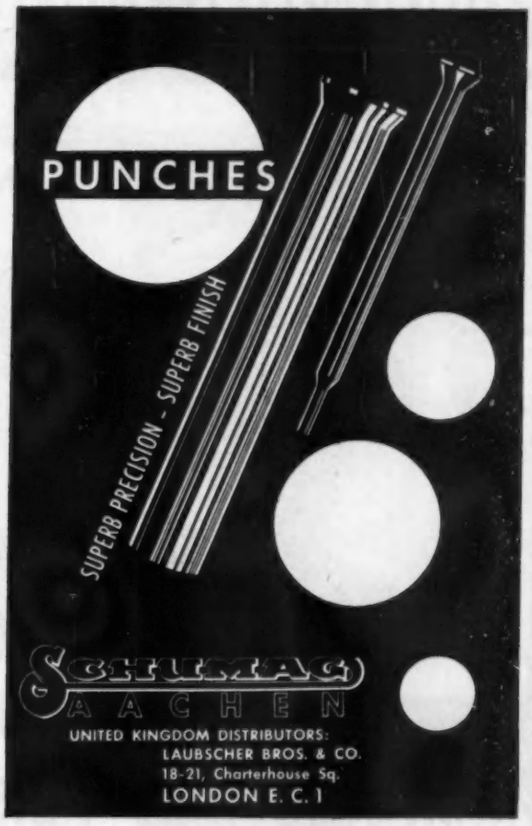

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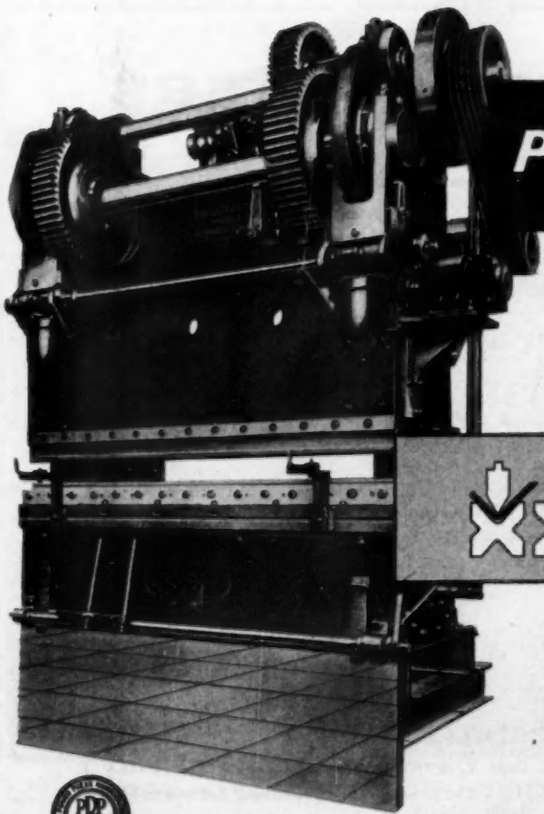
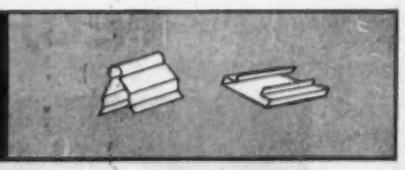
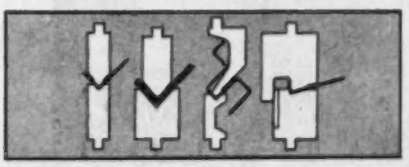
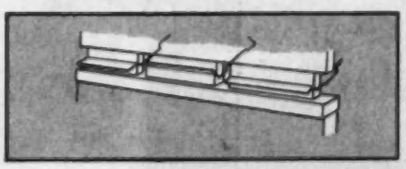


PRESS BRAKES







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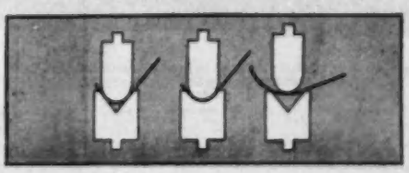

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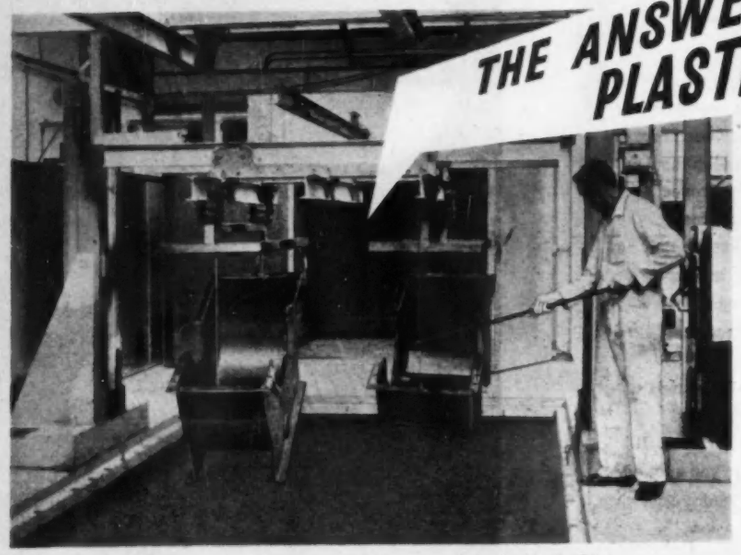

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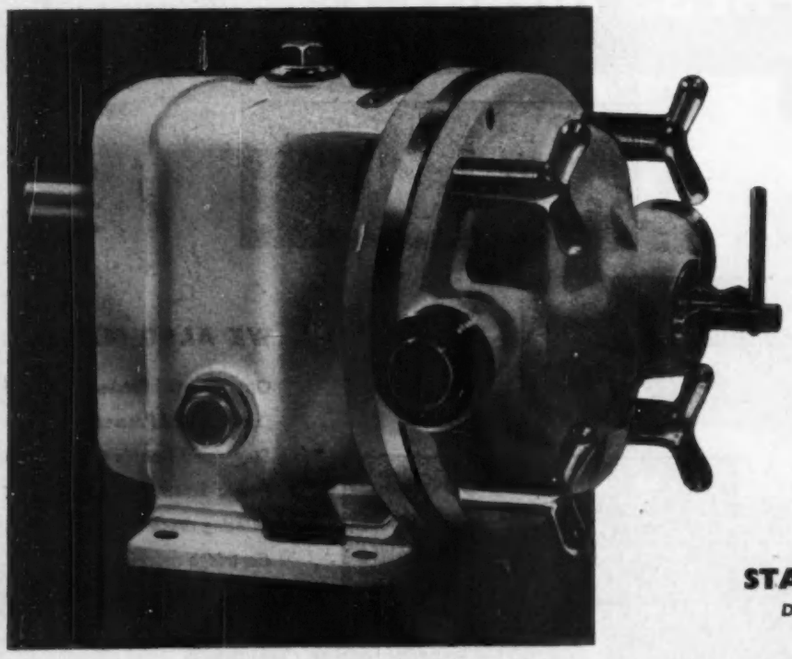

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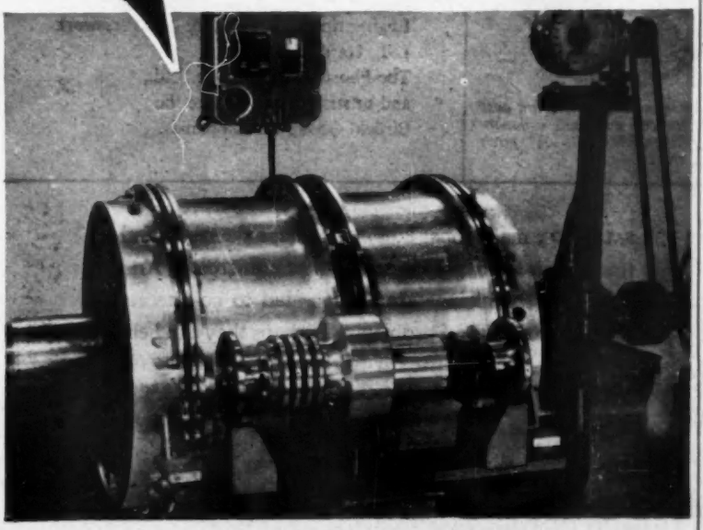

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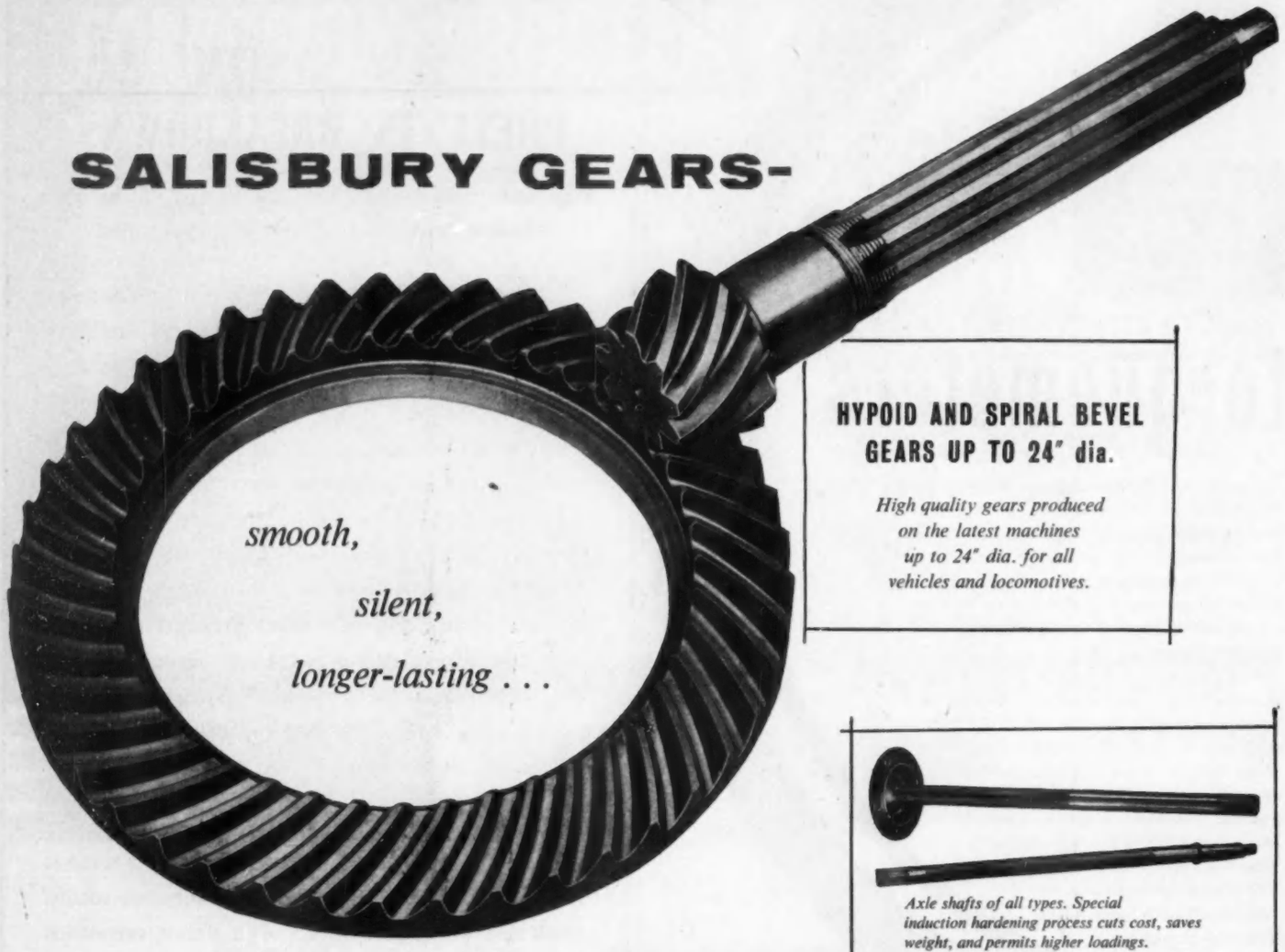

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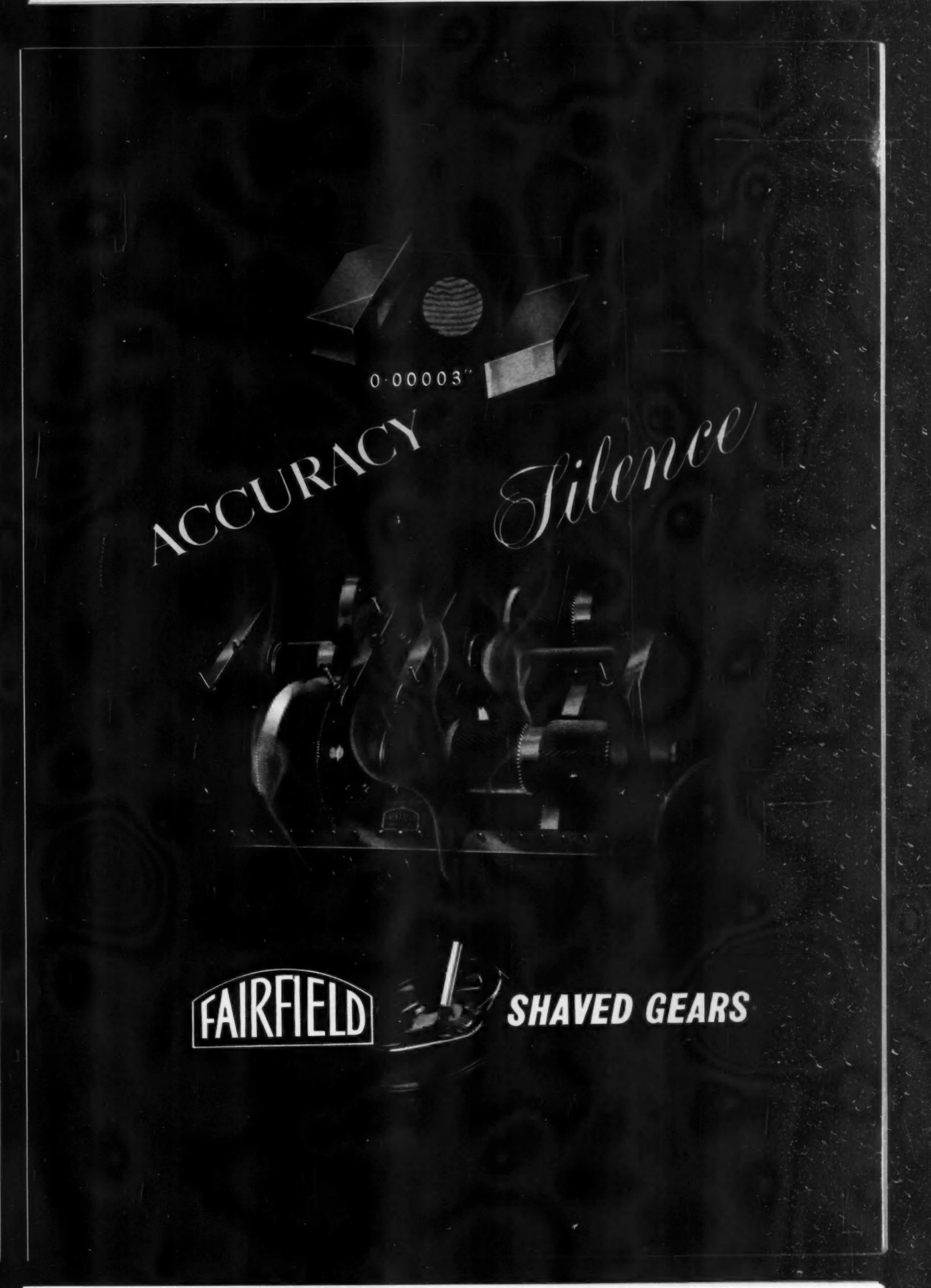
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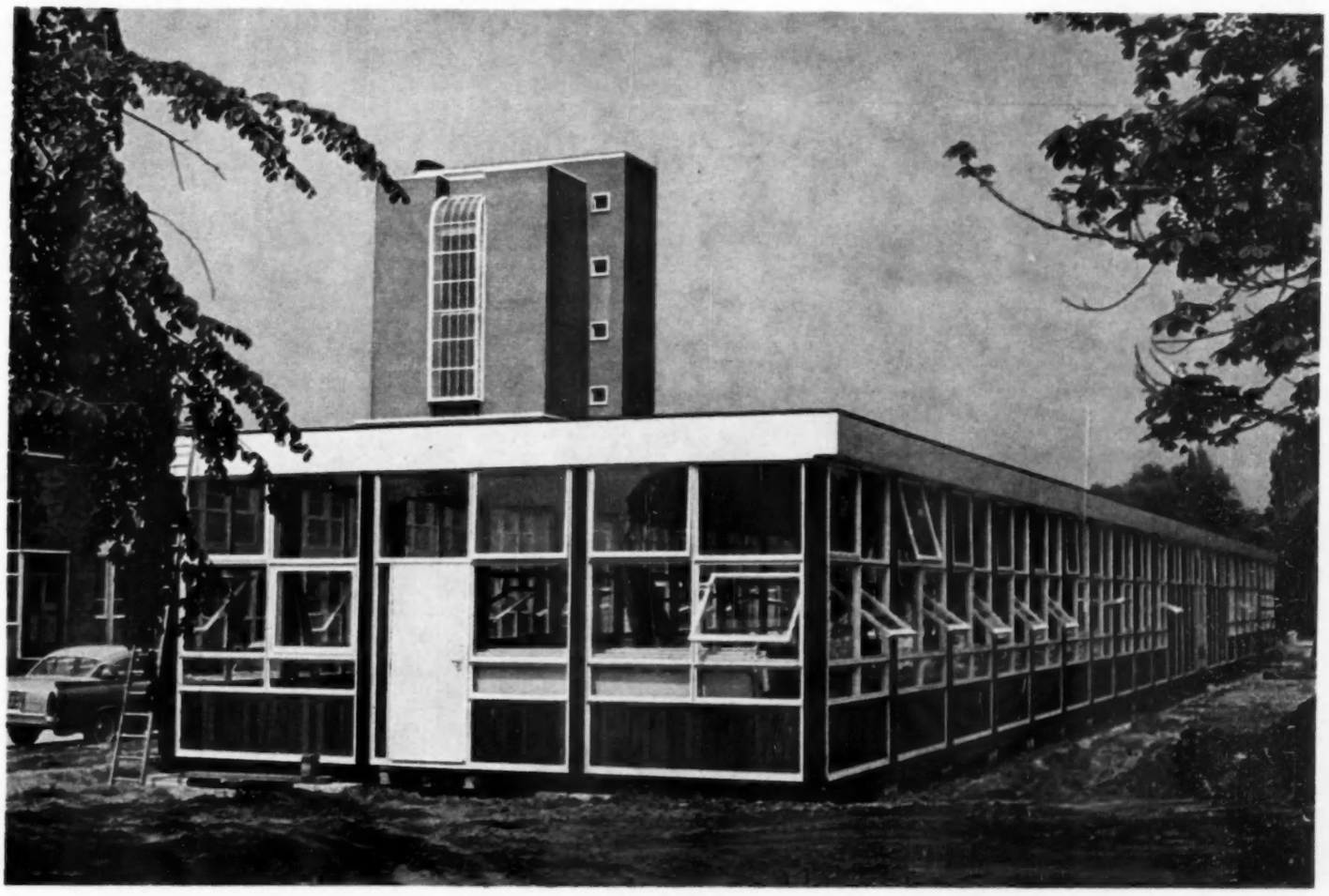

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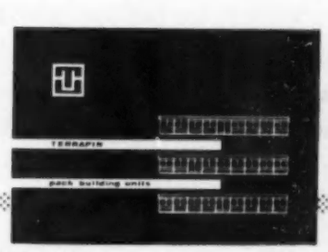

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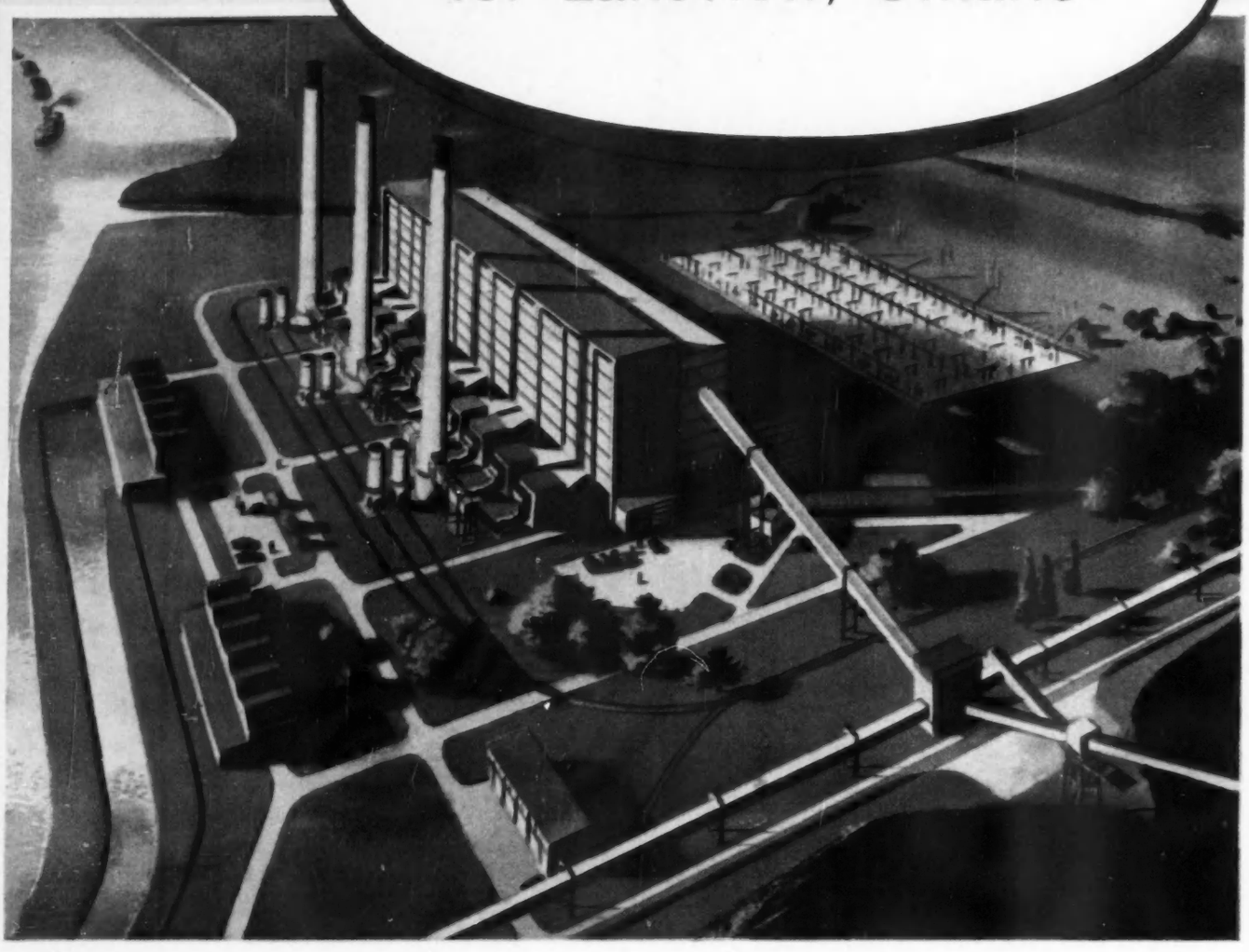

From an original drawing supplied by the Hydro Electric Power Commission of Ontario

THIS artist's impression shows the Lakeview Generating Station now being built beside Lake Ontario. With its planned capacity of 1,800 MW, it will be one of the world's largest thermal-electric plants. Two 300 MW turbine-generators have been ordered from AEI and the first will be installed in 1963. These generating sets, like all AEI equipment, will incorporate advanced design based on long experience.

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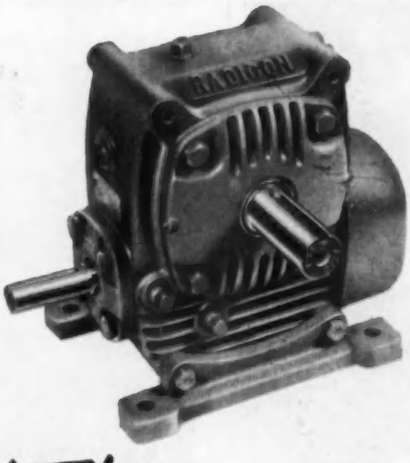

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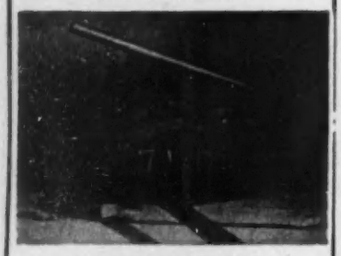

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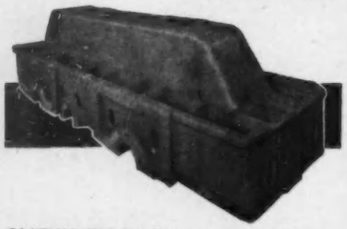

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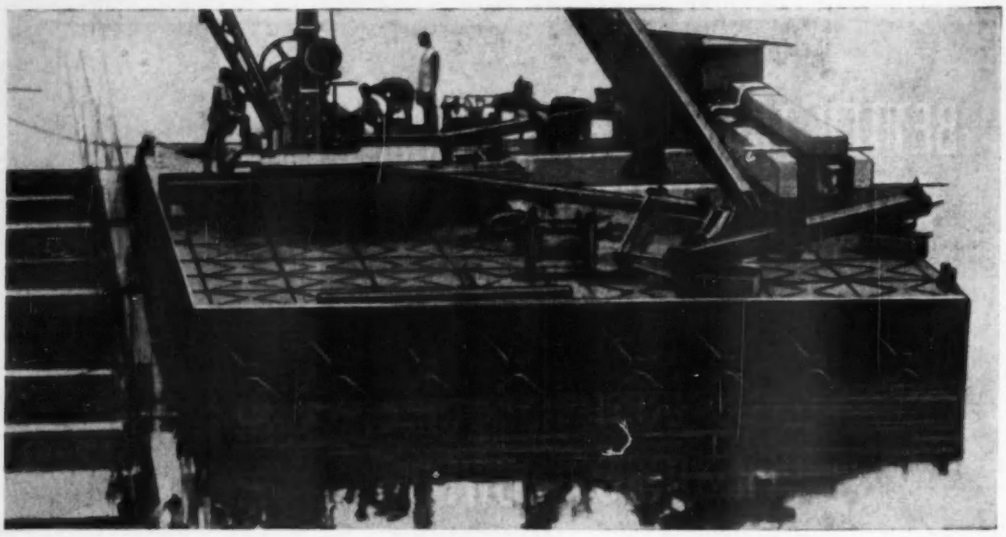

Braithwaite Coffer Dams

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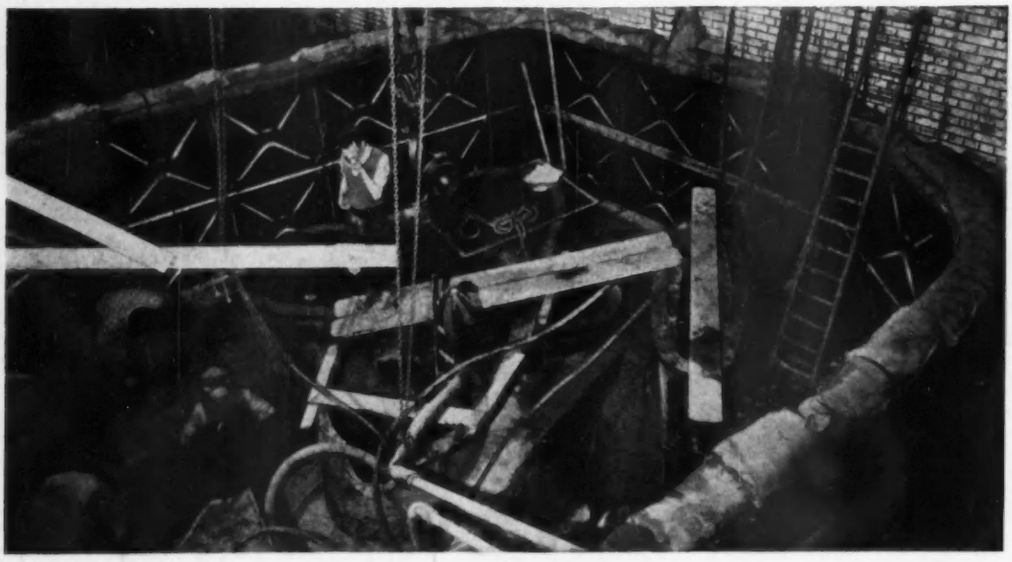

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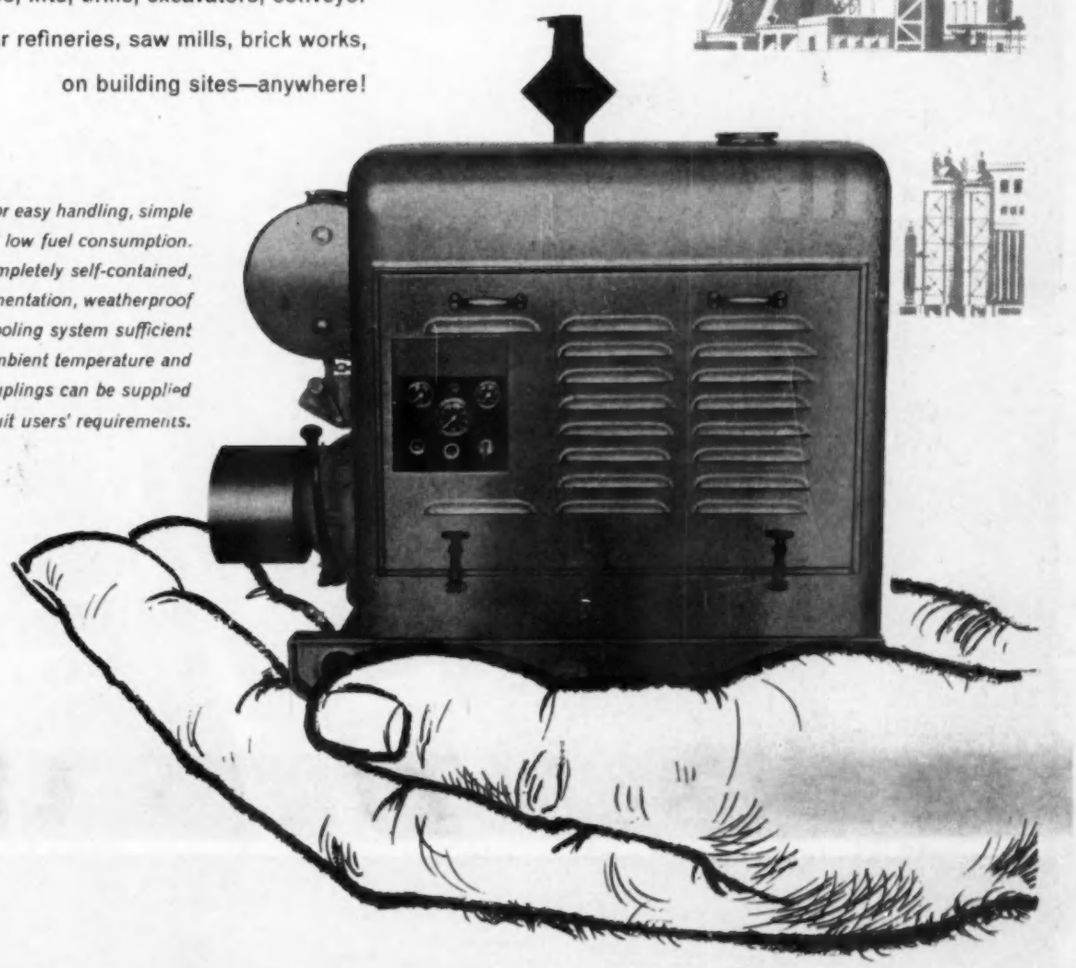
The engines range from 17 to 71 h.p. and provide a source of power for pumps, lifts, drills, excavators, conveyor belts—in sugar refineries, saw mills, brick works, on building sites—anywhere!

Designed for easy handling, simple maintenance and low fuel consumption. They are completely self-contained, with full instrumentation, weatherproof cowlings, a cooling system sufficient for 50° C ambient temperature and the output couplings can be supplied to suit users' requirements.



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DIESEL POWER UNITS

Illustrated literature and information available from :

MERCEDES-BENZ (Gt. BRITAIN) LTD | INDUSTRIAL DIESEL ENGINE DIVISION, GREAT WEST ROAD, BRENTFORD, MIDDLESEX. Telephone : ISLeworth 5341

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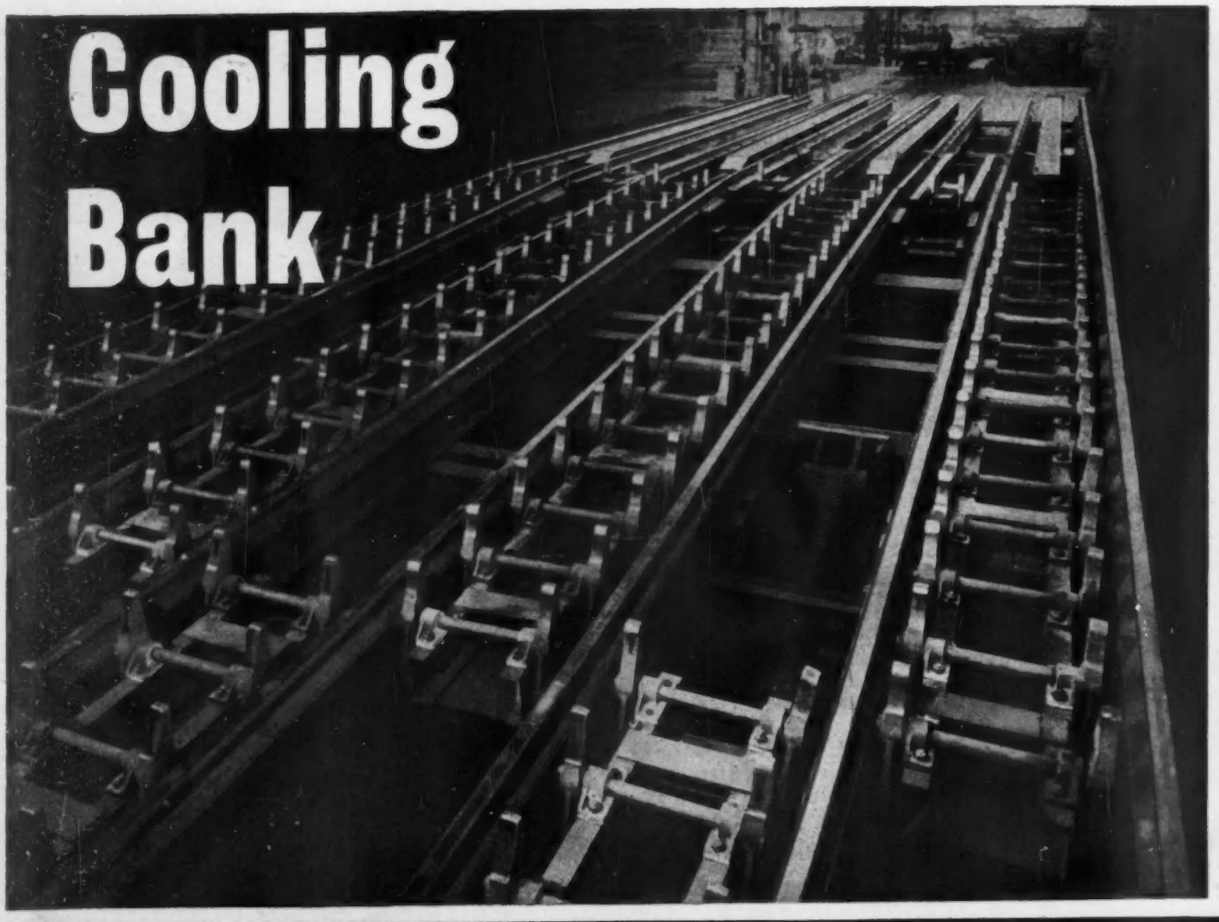
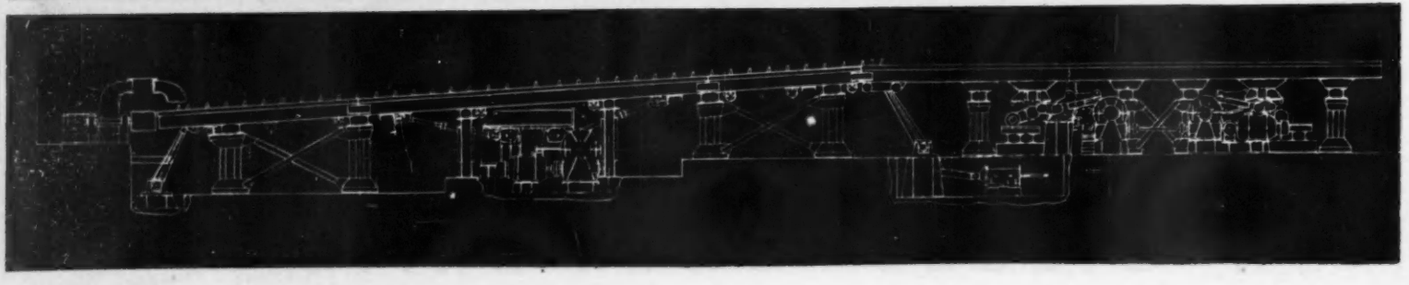
Billet Transfer and Cooling Bank

This bank was designed to receive billets from the hot shear run-out table of the Billet Mill, transfer them singly whilst cooling and marshal them for off-loading when cool. By this method the billets are not deformed during handling. It is suitable for billets of 4″ square by 18′ 0″ in length. The length of travel being 85′ 0″ at a maximum speed of 20′ 0″ per minute.

Photograph by kind permission of the Park Gate Iron & Steel Co Ltd



another **THORNTON** contract



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Huddersfield 7541

B Thornton Ltd. *Engineers & Contractors,* Turnbridge, Huddersfield

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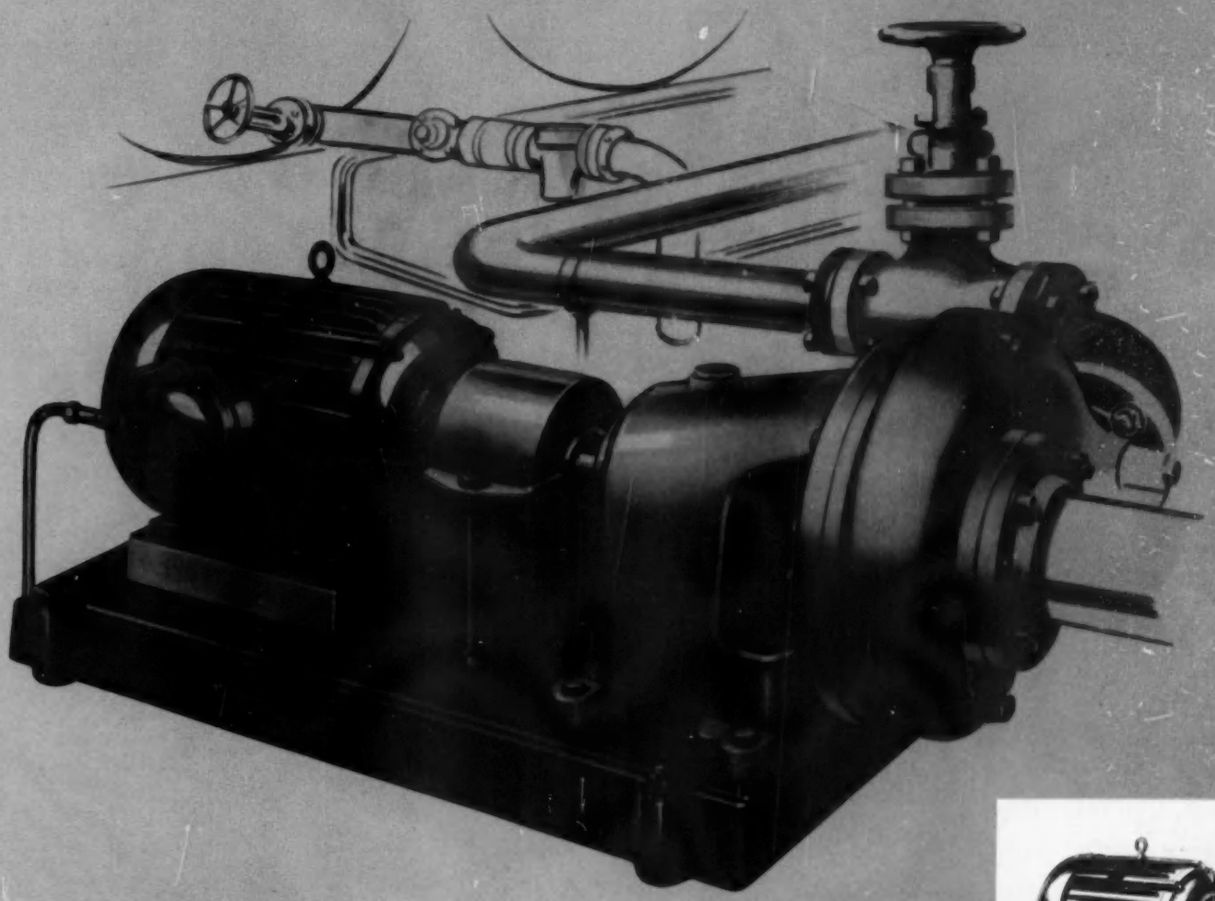
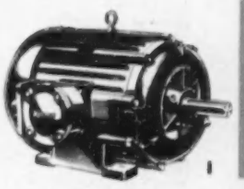
Newman
MULTI-RANGE MOTORS





1

Nº4 Flameproof motors

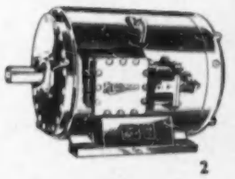
In this field of electric motor design and manufacture, more than in any other, Newman is an acknowledged leader.

There is a Newman motor for almost every kind of hazardous duty in practically any part of the world.

In addition to the fully approved flameproof and explosion-proof motors to meet Buxton or U.S.A. Underwriters' Laboratories standards (Newman is the only British company to have both approvals) there are also modified versions of these designs specially suited to the needs of ordnance factories and gasworks and meeting the specifications of these industries.

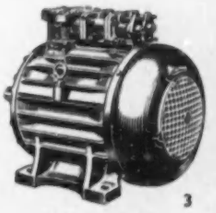
Every Newman motor is built and tested to the highest standard of quality.

1. **BUXTON CERTIFIED** or **UNDERWRITERS' APPROVED**
1/2-200 h.p.
British or American Standards.
New NEMA Dimensions.
(List No. 703).



2

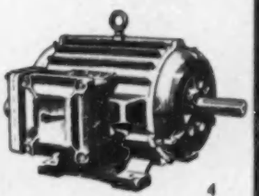
2. **BUXTON CERTIFIED**
Steel Barrel Type.
5-200 h.p.
British Standards.
(List No. 702).
(also available to NEMA Dimensions).



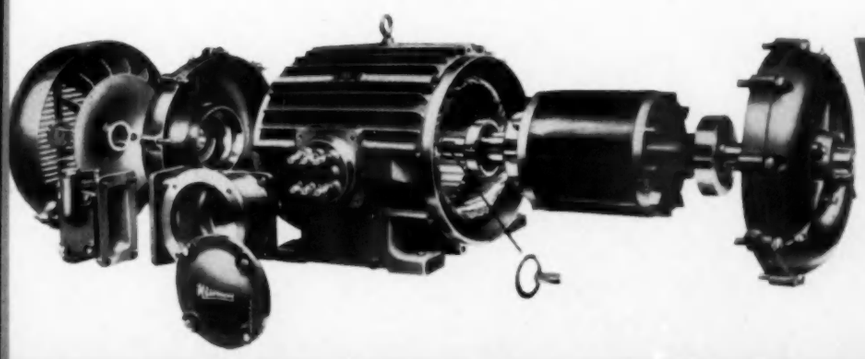
3

3. **BUXTON CERTIFIED**
1/6-50 h.p.
British Standards.
(List No. 701).

4. **GASWORKS TYPE**
1/2-250 h.p.
British Standards.
(List No. 308).

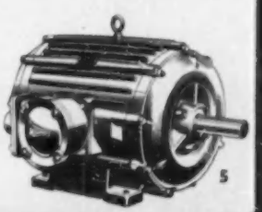


4



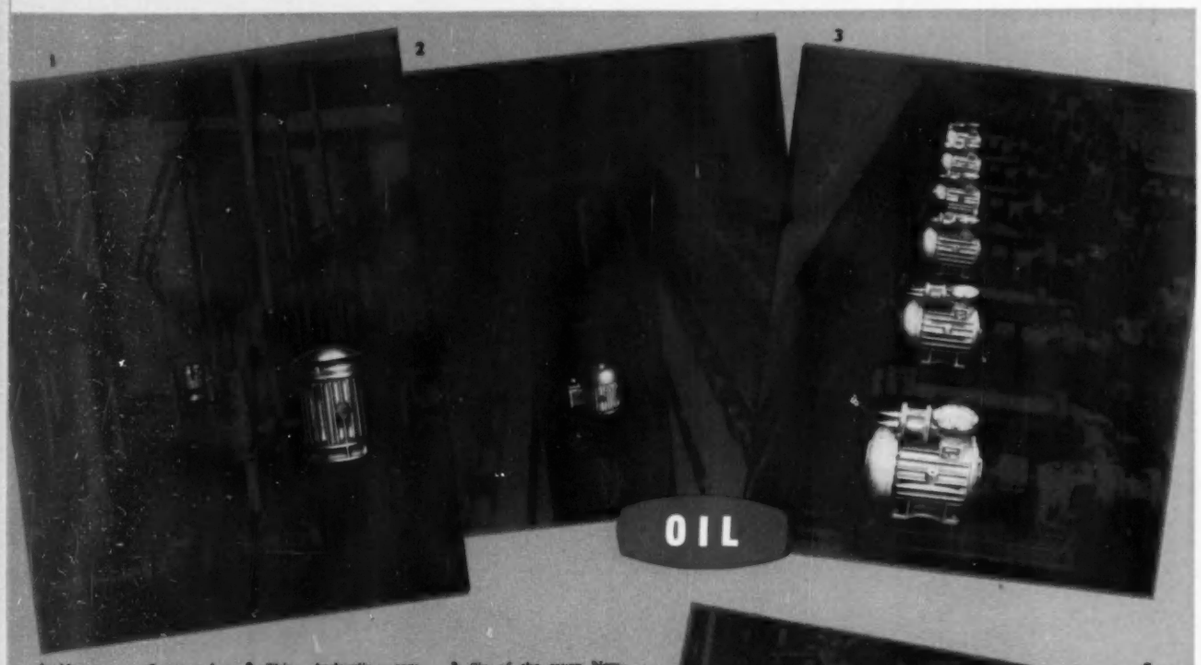
Newman

5. **ORDNANCE FACTORY TYPE**
1/2-12½ h.p.
British Standards.
New NEMA Dimensions.
(List No. 307).



5

Flameproof motors at work



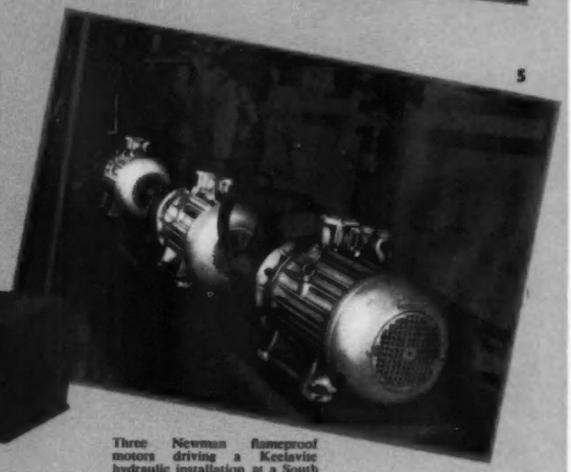
OIL

1 Newman flameproof motors driving pumps at the Fulham Bulk Plant Depot of the Esso Petroleum Co. Ltd.

2 This hydraulic ram (powered by a Newman Explosion-proof motor) is installed in what is reputedly the World's largest circular building (geodesic domed) at Baton Rouge, Louisiana, U.S.A. The building houses the regional tank car repair and maintenance facilities of the Union Tank Car Company.

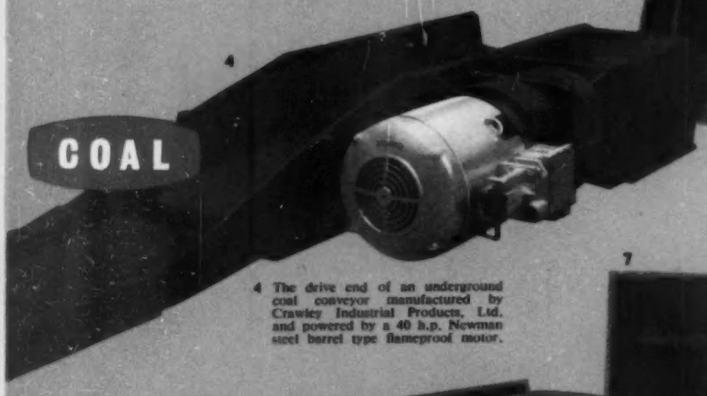
3 Six of the seven Newman flameproof motors installed at the Power Petroleum Company's Wakefield Depot for driving tanker loading pumps.

photo by courtesy of Shell Mex and B.P. Ltd.



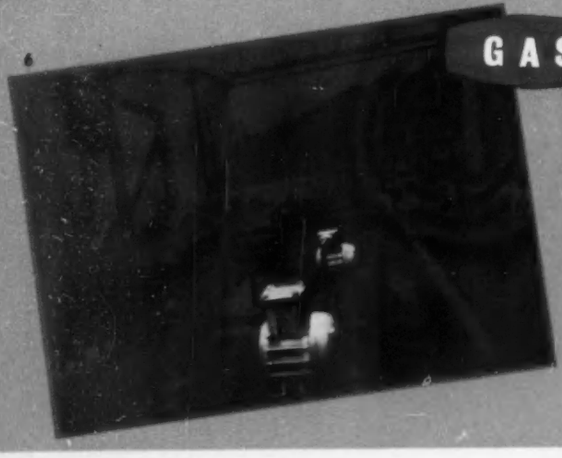
Three Newman flameproof motors driving a Keelavite hydraulic installation at a South Wales Colliery.

photo by courtesy of "Colliery Engineering."



COAL

4 The drive end of an underground coal conveyor manufactured by Crawley Industrial Products, Ltd., and powered by a 40 h.p. Newman steel barrel type flameproof motor.



GAS

6 & 7 The South Western Gas Board uses Newman flameproof motors extensively throughout its area. Here are two "P.F.D." (Primary Flash Distillate) pumping installations; Weston-super-Mare (left) and Turo (right).

Newman

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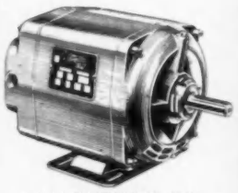
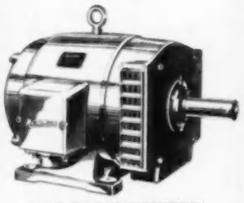
604 Cogent

THE NEWMAN RANGE

Some of the other types of Newman motors available

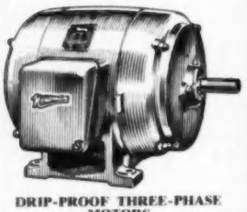


ELF FRACTIONAL H.P. MOTORS
British Standards.
NEMA Dimensions.
1/16-1 h.p.
(List No. 501).

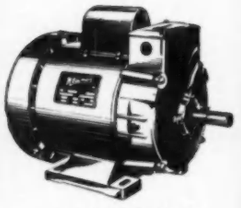


DRIP-PROOF SQUIRREL CAGE MOTORS
British Standards.
15-600 h.p. (List No. 103).
American Standards.
15-600 h.p.
(List No. 104).

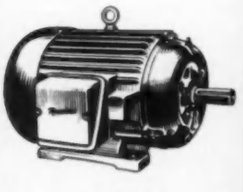
STEEL FRAME FRACTIONAL H.P. MOTORS
British Standards.
NEMA Dimensions.
1/8-1/2 h.p.
(List No. 502).



DRIP-PROOF THREE-PHASE MOTORS
British Standard Dimensions.
1/2-50 h.p.
(List No. 101).
New NEMA Dimensions.
1/2-150 h.p.
(List No. 102).



66-FRAME MOTORS
British or American Standards.
NEMA Dimensions.
1/2-2 h.p.
(List No. 503).



TOTALLY ENCLOSED THREE-PHASE MOTORS
British Standard Dimensions.
1/2-40 h.p.
(List No. 301).
New NEMA Dimensions.
1/2-40 h.p.
(List No. 300).

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The illustration shows a Rectifier Control Grid, a Rectifier Anode, a Boat, a Bearing, two Gland Rings, a Piston Ring, a Tube and a Valve Anode—just a small selection of products showing the remarkable versatility of Morganite Carbon.

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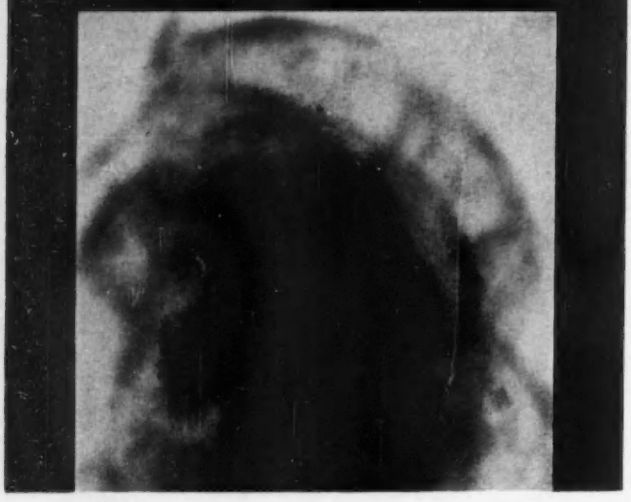
HIGH PRESSURE STEAM IN CHECK



Crane recently added to their wide range a series of gate, globe and check valves in Forged Steel. These valves are designed for long service in severe working conditions. A varied trim selection makes them applicable to many different services, including chemicals of a corrosive nature, and steam at high pressures and temperatures up to 1,000 degrees F. Crane Forged Steel Valves are made with screwed or socket-welding ends to British and American Standards. Sizes range from ¼" to 2".

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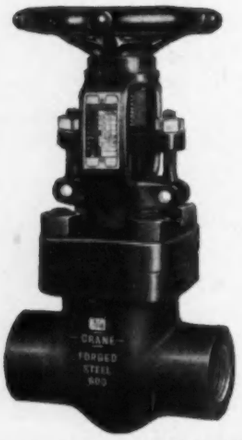
Works: Ipswich

Branches: Birmingham, Brentford, Bristol, Glasgow, Leeds, London, Manchester.



the toughness of forged steel valves by **CRANE**

VII

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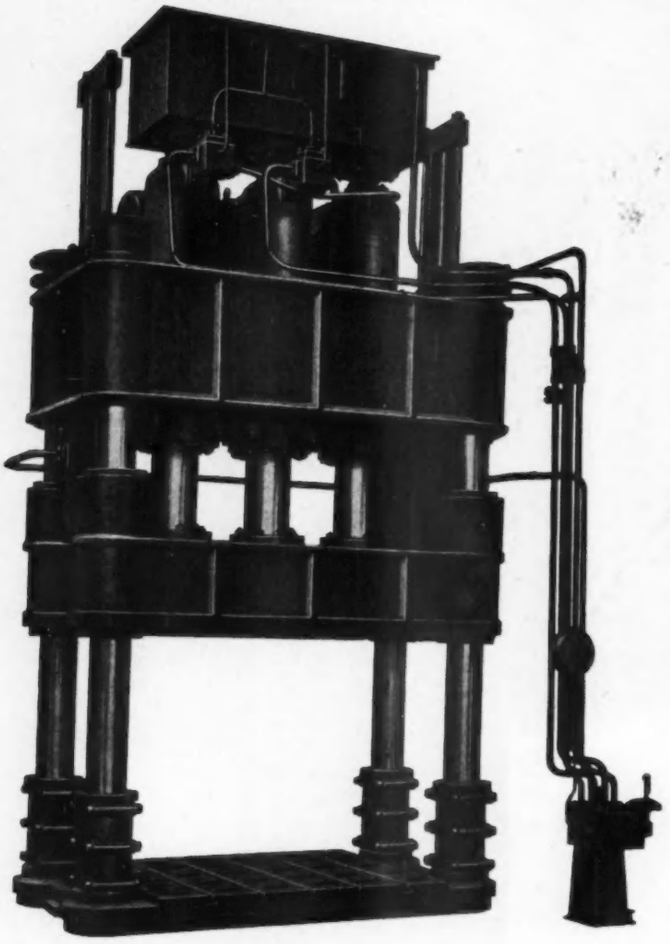
HYDRAULIC PRESSES



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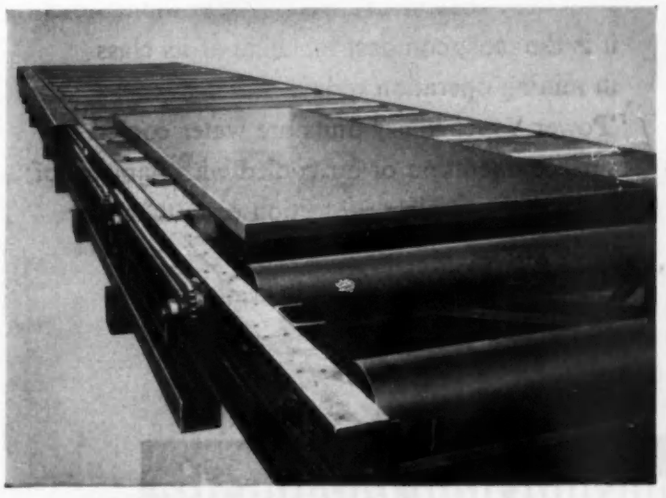

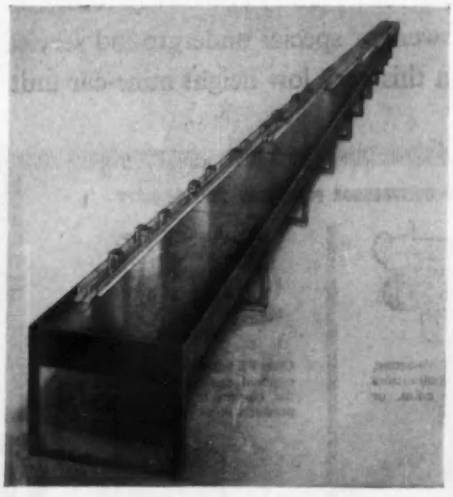

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Slat Conveyors
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Gravity Roller Conveyors
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Elevators, etc. etc.

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These photographs give an idea of the wide range of our products and the variety of applications for which they are specially designed.
Left: A heavy duty, powered roller conveyor carrying 2in. thick steel plates.
Right: A 100ft. long conveyor with twelve separate belts carrying ¼ lb. packets of tea.

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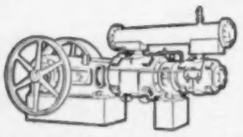
Although the standard 'Power Vane' rotary stationary compressor has different dimensions it is the most compact machine of its class in mining operation today.

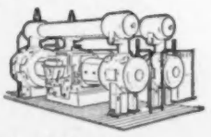
'Power Vane' rotary units are water cooled for surface operation or air cooled with flameproof drive and complete protection equipment for underground service.

Comprehensive literature is available on request.

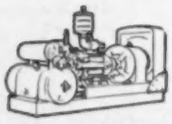
THERE IS A CP COMPRESSOR FOR EVERY TYPE OF DUTY



Class T straight-line, double-acting, single and multi-stage compressors for outputs up to 745 c.f.m. or pressures up to 2,500 p.s.i.



Class FE balanced-opposed multi-cylinder compressors for outputs up to 8,000 c.f.m. or pressures up to 3,000 p.s.i.



Class RE electrically driven Rotary Air Compressors for outputs up to 510 c.f.m. at 100 p.s.i.

Class P two-stage air-cooled compressors for outputs up to 477 c.f.m. at 100 p.s.i.

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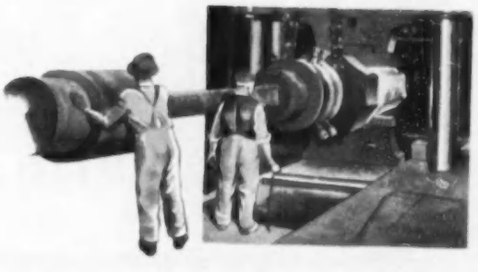

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The assembly line of Ford Motor Company Ltd. at Dagenham, where "Broomwade" compressed air equipment is used. *Photograph by courtesy of Ford Motor Company Ltd.*

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Steam Conditions:		
	Pressure	2,350 p.s.i.g.
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	Reheat Temperature	1,050°F

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Two 275 MW single-line units for Blyth 'B' station
Two 350 MW single-line units for Drakelow 'C' station

AND NOW . . . Instructions have been received to put in hand TWO 350 MW single-line units for Blyth 'B' station.

'ENGLISH ELECTRIC'

steam turbo-alternator sets

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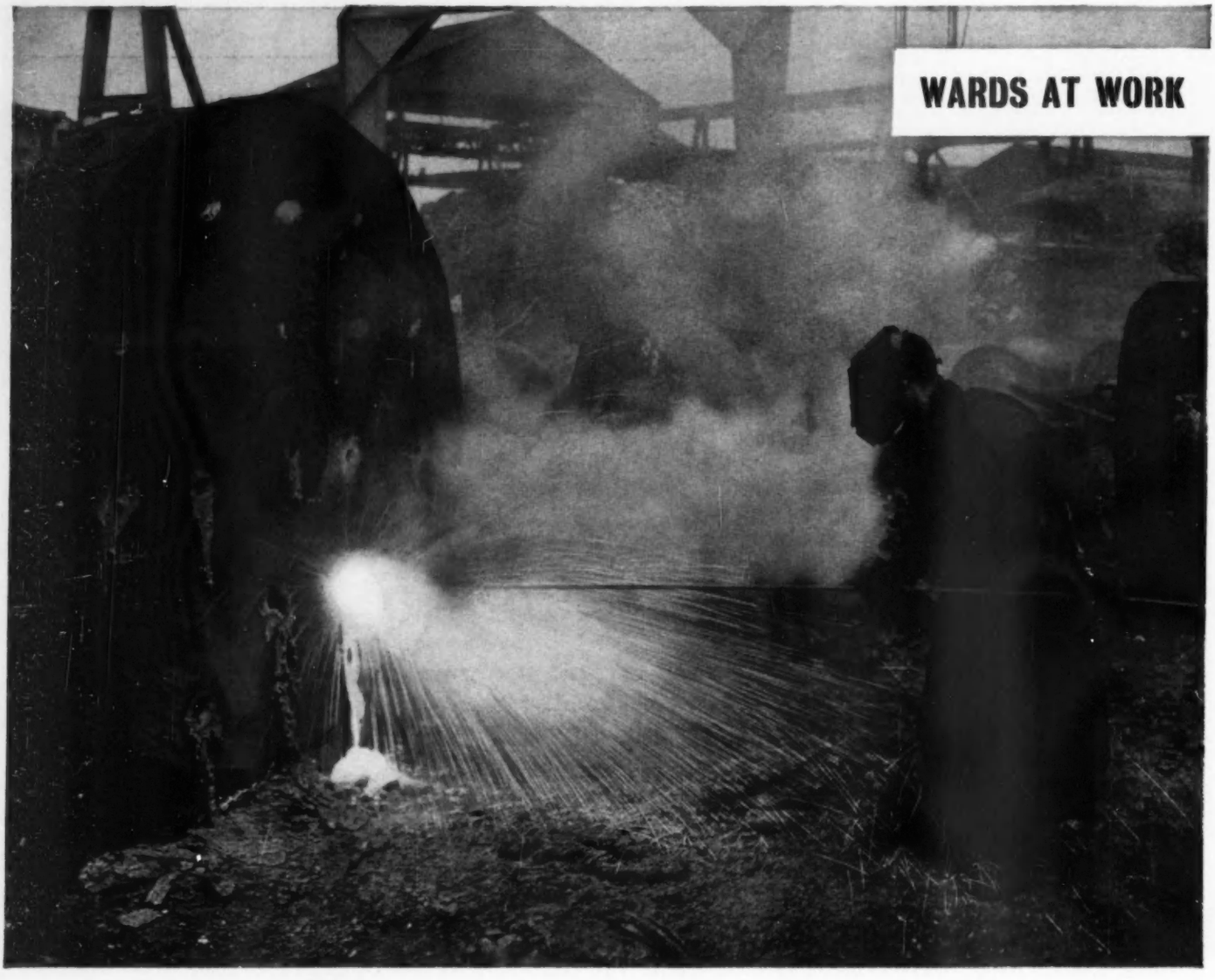

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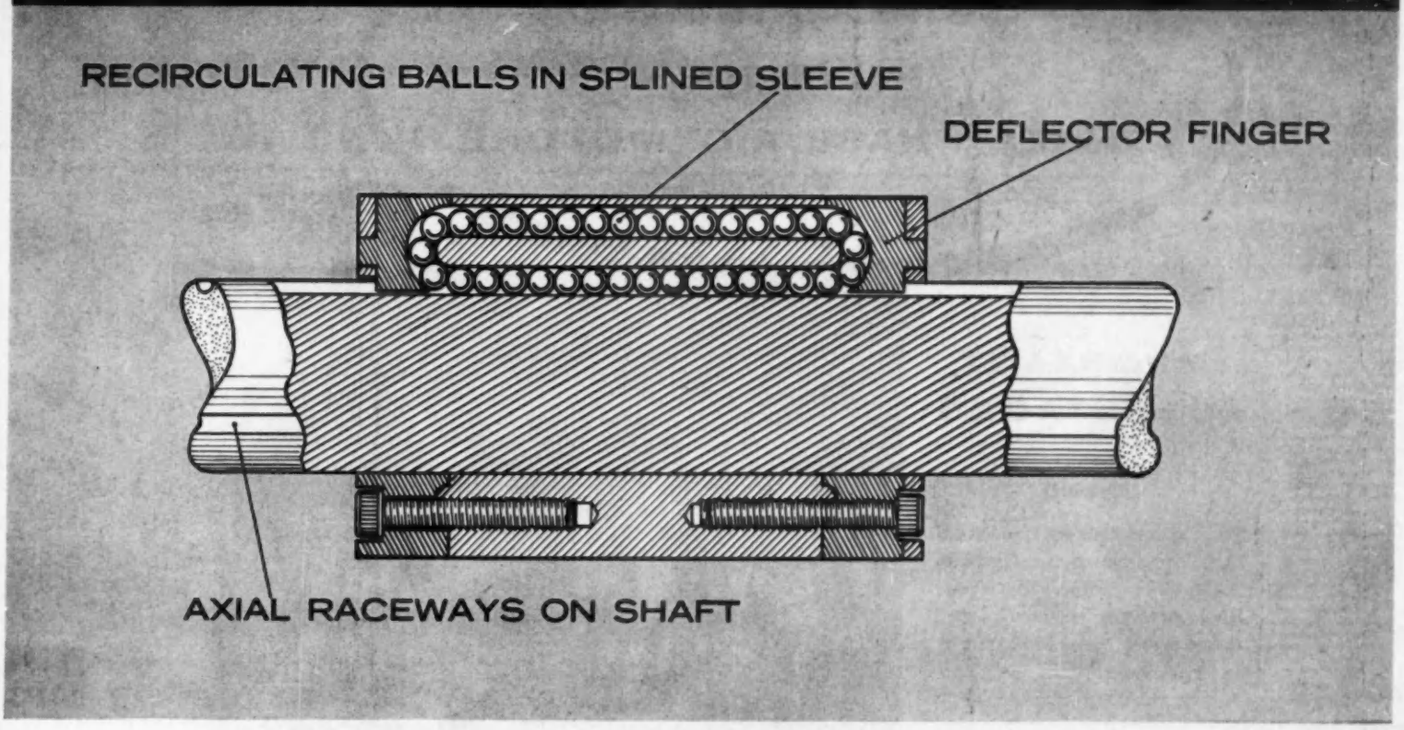

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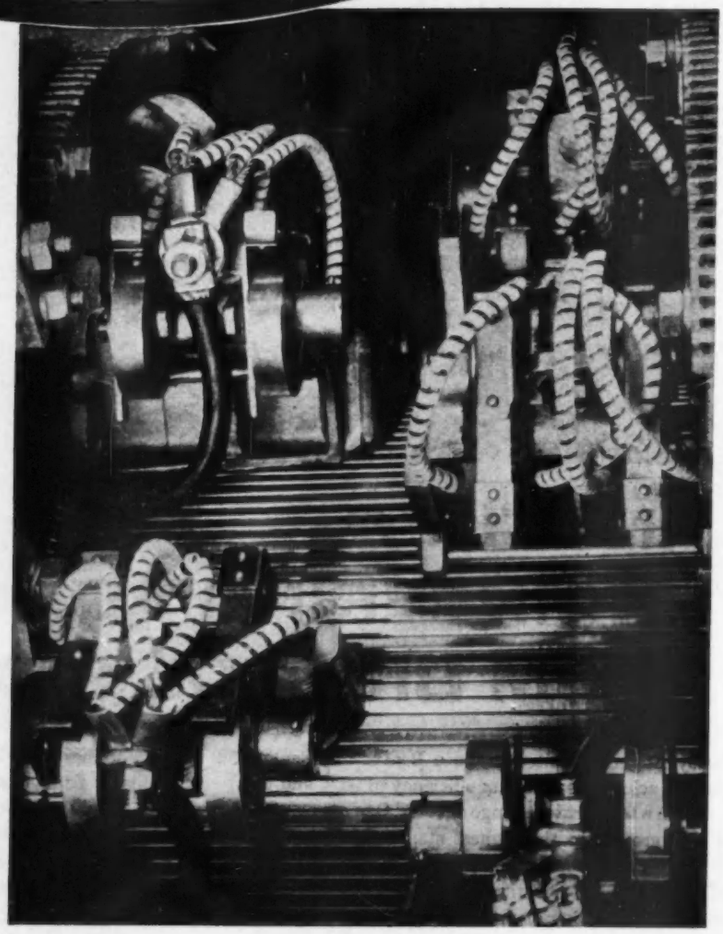

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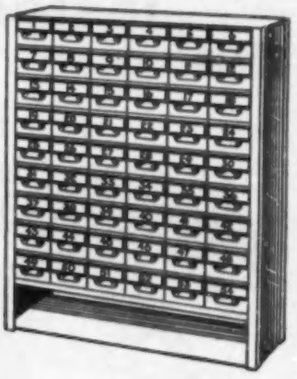

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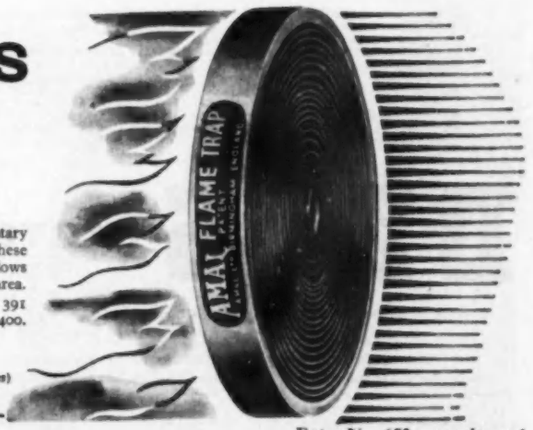

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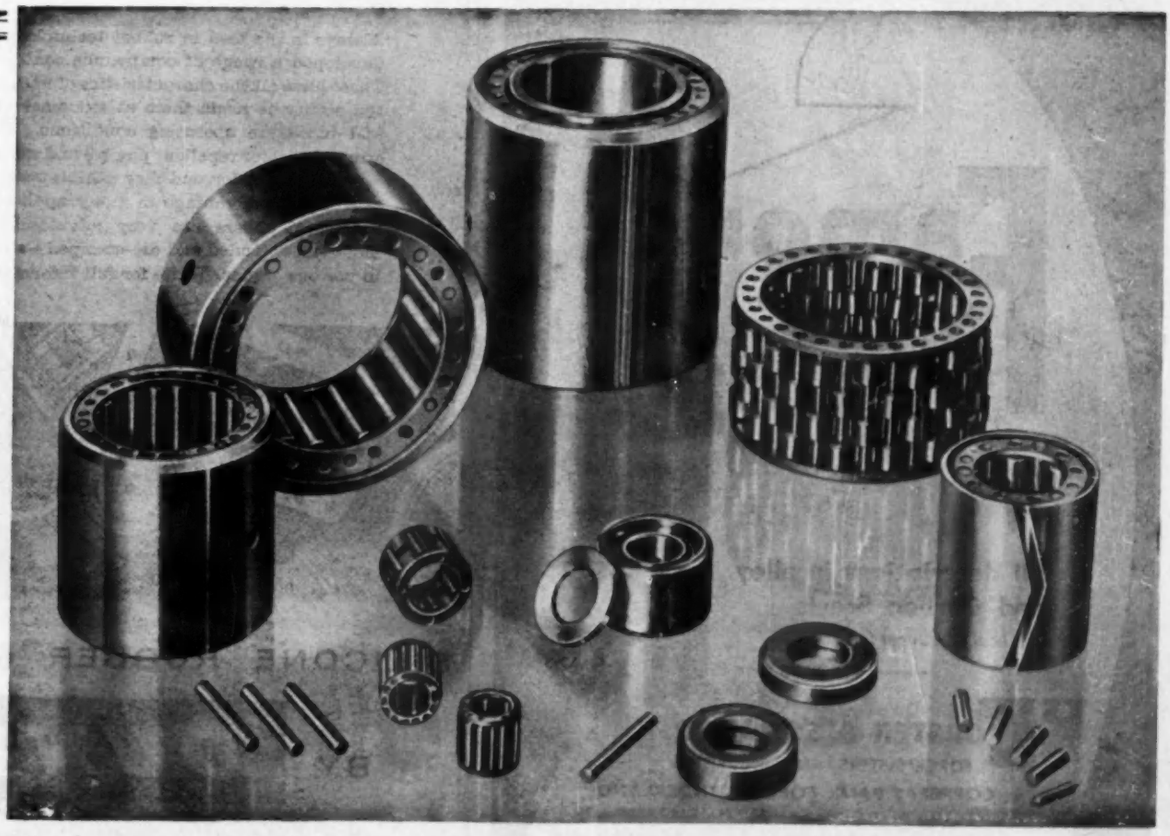

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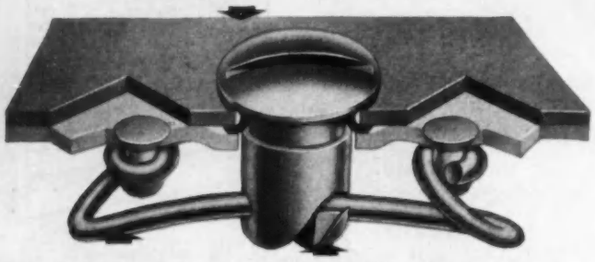

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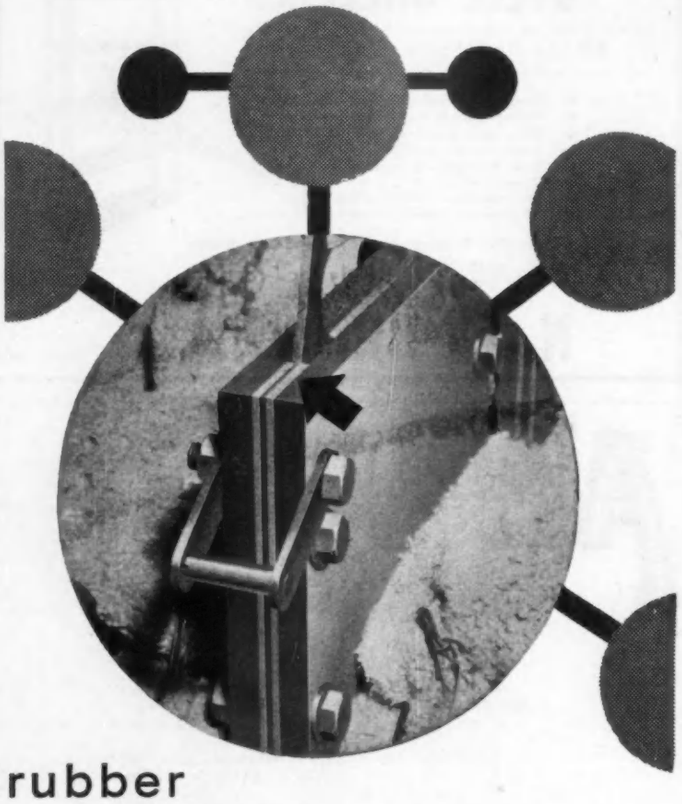

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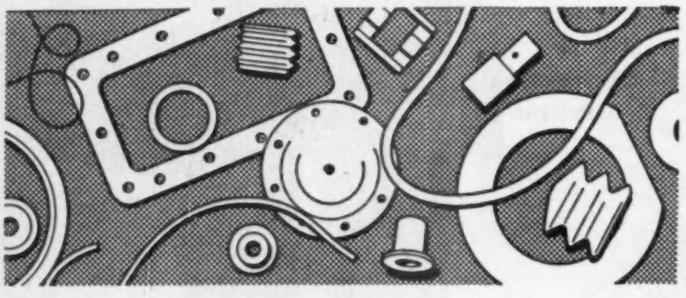

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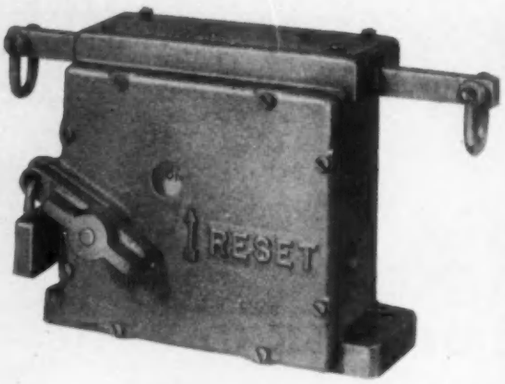

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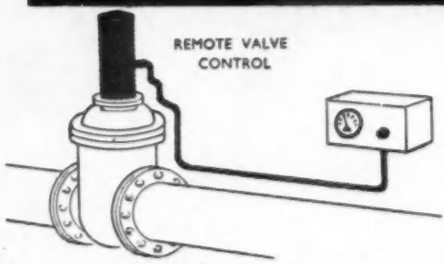

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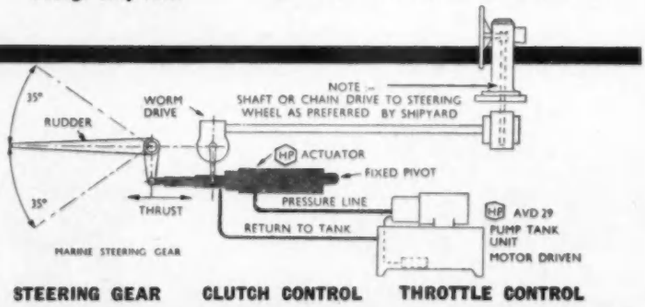

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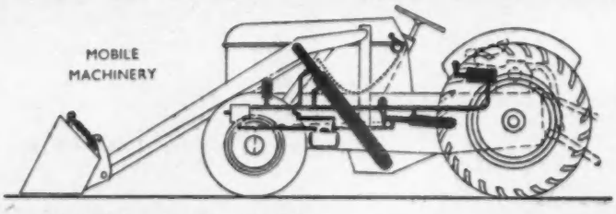

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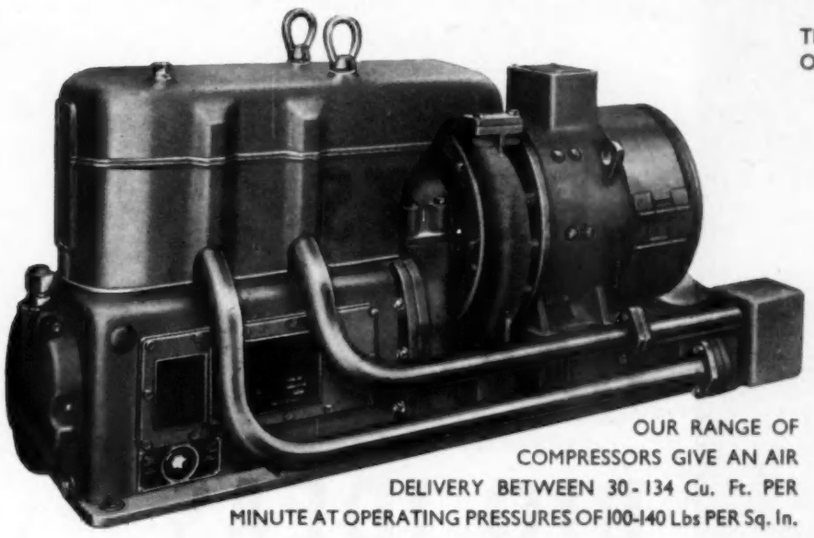

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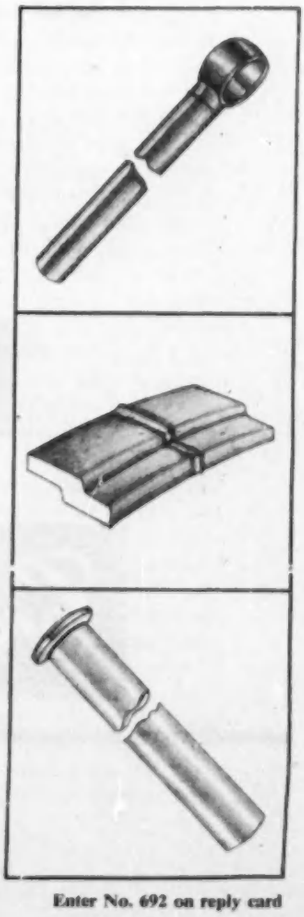

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THE ENGINEER

No. 5459 SEPTEMBER 9, 1960 Vol. 210

REFLECTIONS IN THE WINDOW

A shop window can generally, if not necessarily, be seen through in two directions, and it is perhaps fruitful to apply this property to the metaphorical shop window of the British aircraft constructors, the S.B.A.C. Flying Display and Exhibition, and study the customers as, we trust, the shopkeepers themselves are even now doing. Much as engineers may sympathise with the aircraft industry in the ominous opening of its second half-century, it is hardly to be disputed that among the customers are to be seen agencies whose strength is not merely beneficial but necessary to the survival of the community in a recognisable from, and which should be, if not is, of prime interest to every citizen.

The first customer to occur to most minds will doubtless be the Royal Air Force. The R.A.F. of today can hardly be discussed in the language formerly applied to it; it has just become the fifth air force with supersonic fighters (excluding deck-landing aircraft) and is certain to be at least the fourth to introduce supersonic equipment for offensive missions. No study can escape the facts that the Royal Air Force is still waiting for a military version of the civilian version of a transport aircraft it failed to order four years ago, that it is now the custodian of a fleet of artillery weapons to transport which it is dependent upon a foreign air transport service, and, unkindest cut of all, that it is expected to operate old and even second-hand air liners. However, even if the Royal Air Force no longer demands the uttermost performance that the weapon designer can achieve, it must still buy some aircraft from somewhere, and there are some things, such as an active homing missile, that it needs desperately. But as well as needing arms, the services want an industry to back them up and provide spares, repair services, advice and fresh ideas, and the object of a procurement policy is often as much the building up of an industrial base as the provision of weapons. The erstwhile procedure of issuing specifications, studying numerous submissions, building a plurality of prototypes, and at length initiating production has become impossibly expensive in time and money, and the most that is hoped for now is that there should be at least one firm which knows the business of developing, say, manned interceptor systems, and knows that it is its business. This latter demand is no more than discreet if the fighting service expects to have a reasonable prospect of being able to discharge its long-term commitments; once the service loses the respect of its suppliers it will certainly not retain that of its opponents. The industry as it stands at this time must therefore present an unattractive aspect to the forward-looking planner: the majority of the firms have heavy commitments connected with civil aircraft, and the fact that the performance and delivery dates of these are public knowledge can only tend to give the civilian work the inverse of the importance it ought to have. There is even an enhanced danger that a commercial failure may endanger the provision of vital military stores. The difficulties in the way of obtaining military aircraft as required and when required become more daunting the closer they are studied: companies, like individuals, tend to have characters, and one hardly dares to hope that there exists a firm which can take either the attitude that "an aeroplane must be able to support itself in the air — financially" or "nothing is more expensive than the second best weapon in the conflict," as the customer may choose. That the Royal Air Force should be bereft of its powerful purchasing position at a moment when it is without any weapons, delivered or on order, for use in the minor, peripheral or "brush-fire" wars, fought in unknown countries far from prepared bases, may have the gravest consequences.

The Royal Navy would appear, in a period when mobility is becoming increasingly important, to be a rich and reliable customer for aircraft, but a closer study does not completely confirm this. The difficulty of making the aircraft compatible with an aircraft carrier is so great compared to the rather few aircraft that are needed to equip a fleet that only a firm with much experience of naval aviation is normally able to risk undertaking the design and development of a deck-landing aircraft (although the North American "Vigilante" may, it is true, disprove this thesis) and the Royal Navy is at this moment suffering severely from allowing a concern without this specialist background to attempt the task — to such an extent that its "interim" sub-sonic fighter is still in production. Thus the Royal Navy, as well as the Royal Air Force, has very urgent requirements for modern aircraft: in fact, it is largely because the Royal Air Force does not possess equipment for use off unpaved surfaces that the Naval needs are so pressing. The difficulties cited to excuse the absence of runway-less aircraft from the Royal Air Force do not apply to the mobile base, which is naturally endowed with hard standings and ample facilities for cooling them, which has adequate magazines for storing large solid-propellant engines for jet-assisting the take-off in conditions of overload or high temperatures, and which obtains its fuel supplies in bulk and reasonably effortlessly. But, five years after a jet-deflection flat-rising V.T.O.L. was demonstrated — with, it is customary to mention, engines made in Great Britain — it is still the policy of the Royal Navy to continue with catapult launching and arrester-gear landing. This is easily explainable by the fact that a replacement of the "Sea Vixen" cannot be awaited for the length of a normal development cycle. The usual solution to such a crisis is, of course, for the Royal Navy to procure an existing Royal Air Force or United States Navy machine: today one such source is conspicuously unavailable but on the other hand the "Super Tiger", which can launch guided air-to-surface missiles, has been offered to various nations, and the engine that powers it has been selected by almost every N.A.T.O. country except Great Britain. The moment is clearly not far removed when the "bullfighter's jump" must be made—that it has been delayed so late is probably due only to the imminence of the Australian choice of a machine for duties of comparable difficulty. It is curious to note that the fact that

the irrevocable choice, between a short and a long leap forward, has been delayed has made the long leap less, not more, attractive, since the confusion of the British industry in the last few months means that the Admiralty now has little prospect of building up a contractor to dedicate himself to this particularly difficult and specialised field.

To the aircraft industry, it must appear that the army, which complains of a manpower shortage, is potentially an important customer, but its record in the past renders it difficult to place any confidence whatever in its procurement policies. Despite the fact that acquiring modified civilian road vehicles rendered it severely roadbound, the army has proceeded to ignore the prospects of convertiplanes and ground effect machines and order fixed-wing transports of an unparalleled conservatism. The fact that the machines will be imported can only intensify misgivings: to buy in an aircraft other than one from which much is to be learnt is to express the most callous disregard for the indigenous industry.

Naturally far less formidable customers are the nationalised air transport operators, who are in the habit of buying new aircraft at very high frequency in order to gain publicity and perhaps prestige; for a British manufacturer, an airline that is prepared to introduce the "Comet", "Vanguard" and "Trident" within half a decade must seem a blessing indeed. However, the prudent manufacturer is anxious to avoid becoming heavily dependent on their orders, since an airline policy of ordering only machines similar to those other operators have already ordered results in the manufacturer having to economise dangerously on design, development and tooling costs that normally would be spread over numerous aircraft. Because of this extravagant desire for frequent changes in at least the appearance of the aircraft, the machines built for the nationalised fleets are now tending strongly to be devoid of development potential: the "Trident", for instance, rejects irrevocably not only established techniques such as jet deflection to improve approach and climb-out, but the potential advantages of using large portions of the power to modify the flow around the wing. The name of this machine immediately directs attention to the compatriots of the previous "Trident", and it can then hardly fail to be observed that the rear-engined arrangement can have practical advantages for the operator: the distinctive features of the D.H. "Trident" stem very largely from subordination to British Civil Aircraft Airworthiness Requirements, and have but limited market value. The nationalised operators have, so far, been confirmed in their conservative view that the ability to move passengers at low cost is less a qualification for survival than is the ability to secure approval to operate, and there is no good reason why they should take any avoidable risk in order to possess equipment which excels — not here can any ambitious manufacturer expect to find support for a long-term programme to extend the technology of aeronautics.

Study of all the above-mentioned customers is, of course, rendered difficult by the presence of the Ministry of Aviation, which does not even pretend that its sole interest is to supply the operators with the equipment they require. Its policies are at present unknown and therefore beyond criticism, but already there are strong indications that it has inherited the proclivity of the Ministry of Supply for having ironmongery to show for its money, for risking the failure of the aircraft in its rôle rather than the failure of a development programme. The Ministry appears still to be chasing the chimera of common solutions for civil and military requirements, to the extent that it is now proposed to provide the "Britannia" with an automatic landing system demanding a highly accurate instrument landing system, to be laboriously installed and calibrated, and a long level expanse of ground before the threshold, despite the fact that radar-based systems have demonstrated their effectiveness in such difficult environments as the aircraft carrier — the term "strategic" is becoming an euphemism for the unwarlike character of this project. One is also discouraged by the persistence of the Ministry of Supply attitude that it is not obliged to satisfy the requirements of the users but it is prescribed from going beyond them and developing a technique of only potential value. It might well malign the Ministry to suggest that it would allow its obligations to aviators to be modified merely in order that aircraft design and construction should survive in this country, but the tendency for the original, creative engineers to gravitate away from the harsh, demanding duties of day-to-day operation alone would justify encouraging the manufacturers to reconnoitre the frontiers of the state of the art. The original Minister of Aviation was, if nothing else, consistent in choosing always the most conservative and least advanced tool for any given assignment, and his policies could only be expected to lead to the "Rotodyne" débâcle. It is now beyond dispute that the Minister has sufficient authority and influence to defeat or neutralise any venture in fields even faintly connected with aeronautics. To what ends this power will be used remains to be seen.

Happily, there are present at Farnborough customers who approach the constructor directly and who are not interested in presenting a public image, such as the many foreign users of military and civil aircraft and the native "independent" operators. Just at this moment, the potential buyers of civil aircraft are in the happy position that aircraft production has accelerated faster than the demand, and they are undoubtedly aware that British manufacturers are eager to offer favourable terms of trade. But one is entitled to believe that some are seeking machines that are not widely available — perhaps, a specialised freighter with facilities for rapid loading—and manufacturers who have such products can expect to do business and to earn not only money but a valuable feedback of experience.

DESIGN APPRECIATION FOR ENGINEERS

We learn that the Council of Industrial Design is arranging a course in design appreciation for apprentices and junior engineers from both light and heavy engineering industries. It will be held near London in November and December of this year, and will be arranged in two residential periods, each of four days, separated by an individual study period of three weeks. A detailed programme is now being prepared and will be available shortly. The decision to arrange the course arose out of the success of an experimental course held at the end of 1959 for ten students. Deservedly it brought in so many inquiries that the Council has been prompted to consider planning a series for junior and senior engineers at regular intervals to suit any organisation which can send sufficient engineers to one course, or by inviting engineers from one industry or group of related industries. It is not, of course, the aim to attempt to teach industrial design in so short a course, but rather to make members aware of design, first in its widest context—in

the domestic, public and industrial fields. Then the design of particular products will be examined in detail to develop the students' analytical abilities and finally they will be required to make recommendations for improving the design of selected goods. The exact form of the courses will, we understand, depend upon the age of the members, the type of engineering industry and the periods most suitable for those who can join; but the factor common to all is the development of design awareness. The courses will be residential to give full opportunity for the group discussions and exchange of ideas which proved so fruitful last year. Students will also be able to discuss the analyses and their suggested design improvements with the industrial officers of the Council who have specialised technical knowledge of the problems and needs of particular industries.

It is encouraging to find the Council able confidently to plan such courses. For the time is long past when engineers could claim, without harming sales, that utility alone was in their minds in designing products, or hold to the over-simplification that what is functionally fit for its purpose must be beautiful. Good design, æsthetic as well as functional, it is becoming better recognised in the engineering industry, pays dividends in better sales. The council adds that it would be of great help in planning the 1960 course if those interested would apply for further information or enrolment as soon as possible to the Education Section of the Council of Industrial Design.*

SMOOTHING THE WAY

Criticisms of the riding of multiple-unit electric trains is heard at intervals with varying degrees of bitterness. When the rolling stock involved is both new and still in course of production, such criticism deserves more than assurances that modifications to smooth the traveller's way are in hand. Recent letters in *The Daily Telegraph*, complaining of a rough ride in buffet cars of the Kent Coast trains in the Southern Region brought a reply from the technical adviser of the British Transport Commission, who agreed that the riding of vehicles built for the first stage of this electrification was disappointing. He went on to refer to "certain special problems affecting the riding properties of coaching stock which is driven by electric motors suspended from the axles of the vehicle itself." This comment, however, does not point to a complete answer to the problem, for the buffet cars in these trains are not motor coaches and so the axle-hung motor cannot be blamed directly for their poor riding. Indirectly, perhaps, an intensive service of trains with axle-hung motors causes the trouble by punishing the track, although tests carried out by the Southern Region have shown that there is no significant difference in this respect between axle-hung and fully-springborne motors. Moreover, the immediate step being taken to improve matters is to adopt a different bogie for future construction, and not to change the method of motor suspension.

If the Commission is seriously concerned with the problems arising from axle-hung motors, it is surprising that the opportunity was not taken when the rolling stock for the Kent Coast scheme was ordered to give alternative suspensions a further test in service conditions by incorporating fully-springborne motors in some of the motor coaches. This may have been, of course, because it is still in fact an open question whether the culprit is the motor, the bogie, or the multiple-unit system itself. To-day, some thirty years after the question first arose with the adoption of multiple-unit express trains for the Brighton and Worthing electrification of the Southern Railway, it does not seem premature to hope for a clear-cut answer. From the operator's point of view, the high acceleration and consistency of performance with varying loads of the multiple-unit train are attractive. An eight-coach train of the Kent Coast stock has 2000 h.p. distributed between eight axles compared with 2500 h.p. on four axles in the electric locomotives on this route, but when the load is increased to twelve coaches the multiple-unit set goes up to 3000 h.p. on twelve axles. It was stated in another passage of the letter quoted above that vehicles hauled by locomotives do not produce the rough riding problems of the multiple-units, which suggests the question whether performance is being obtained at the expense of passenger comfort. It also makes one wonder why, if axle-hung motors are really to blame, the only exceptions to them on the Southern Region are the fully-springborne motors of the locomotives. There is no obstacle to this method of suspension in motor coach bogies (unless, perhaps, retention of an existing standard design is insisted on) for it is used in the power cars of the diesel Pullman trains. We hope that the modified suspension to be adopted in vehicles for Phase 2 of the Kent Coast electrification, applied to bogies of a design which originated in the U.S.A., will produce the improvements desired. It would be more encouraging, however, if there were clearer signs of agreement as to the roots of the problem before steps were taken to attack it.

* The Design Centre, 28, Haymarket, London, S.W.1. Telephone, TRAfalgar 8000.

The Engineer—100 Years Ago (SEPTEMBER 7, 1860)

"OPENING OF THE BIRKENHEAD STREET RAILWAY"

"Yesterday week was a great day for Birkenhead, and probably also for other great centres of the empire's industry and wealth. Mr. Train's street railway between Woodside Ferry and Birkenhead Park was opened for traffic. In the United States these lines have long been in successful operation, and it is certainly a matter of wonder that it should have been reserved for a Yankee to introduce them into England. However, we may find consolation in the thought that the idea has been developed appropriately enough by a *Train*.

"The length of the line just opened is 2¼ miles, and it is double part of the way. The gauge adopted is 5ft. 2in.; but, in future, that of 4ft. 8½in. (or the narrow gauge of railway) will be taken, which will, as believed be convenient, in many instances for the passage of loaded trucks. The rails have a 6-in. inner surface of flat iron, with a broad rim for the flanges of the carriage wheel, which nowhere rise more than ¾in. above the ground level. Thus, no obstruction is offered to vehicles crossing the rails; but always these vehicles have the chance of running at least one wheel upon the smooth metal instead of on the rough ground. The cost in Birkenhead has been from £1,800 to £2,000 a mile; and it would be greater where the roads are regularly paved. The brake power is applied by the driver by means of a wheel handle, it being held that the treadle motion would be insufficient; and the principle of friction, not of biting the wheels, is employed. Before each pair of wheels there is a broom, or sweeper, to remove stones or other obstacles. Two horses are used to each car; and it is said that a speed of seven or eight miles an hour can be kept up, without distress to the animals or real injury to the roadway.

"Each car is 24ft. in length over all, and 7ft. wide, with a height of 7ft. from the floor to the roof. In the inside there is sitting accommodation for twenty-two persons, whilst, from the great width of the vehicle, standing-room is left for a similar number. On the outside of the cars there is also sitting room for twenty-two persons, for whose protection a handrail is fixed round the top. It will be thus seen that accommodation is afforded for sixty or seventy individuals in each. In the fitting-up, every attention has been paid to the comfort and safety of the passengers. The vehicles have a handsome and luxurious appearance."

1960 S.B.A.C. Exhibition

No. I

The 1960 Flying Display and Exhibition of the Society of British Aircraft Constructors is being held this week at Farnborough ; it is open to the public to-day, tomorrow and on Sunday. We commence below an account of some of the items of technical interest.

The Avro 748 feeder-line aircraft for up to forty-eight passengers has a pair of Rolls-Royce " Dart " engines

THE twenty-first Flying Display and Exhibition of the Society of British Aircraft Constructors showed distinctive differences from its predecessors. An innovation was the inclusion of equipment of foreign origin and not licensed for manufacture in this country ; we understand that the new policy allows foreign products to be exhibited but not demonstrated. This year no ground effect machines appear ; this is not, apparently, a policy decision but merely the result of the only one in the possession of a member of the Society being not entered for the Display.

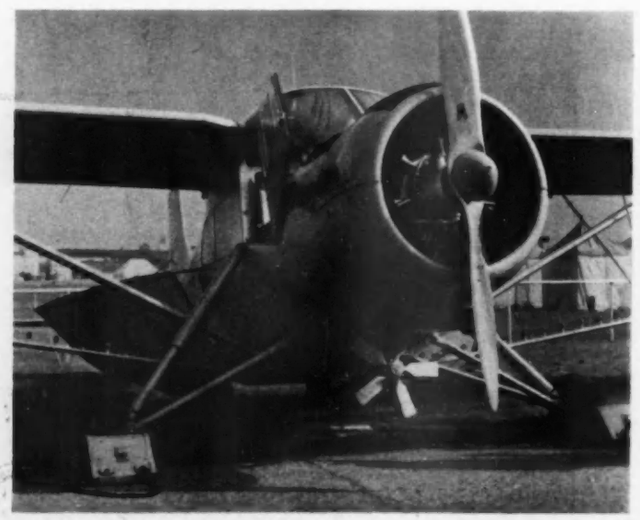
There is but one new aircraft in the Flying Display this year, and therefore instead of, as usual, giving an account of the flying programme we print below some details of the new aircraft and follow with comments on those items of the flying programme which possessed technical interest.

The newcomer to the Exhibition this year is the Avro 748, one of the many projects of Hawker Siddeley Aviation, Ltd. As our illustration shows, this aircraft resembles the Aviation Traders " Accountant " that participated in the 1957 Flying Display more closely than their common power plant and duties alone would explain. In fact, a design team from Hawker Siddeley Aviation studied the earlier machine intimately when that firm was a potential sub-contractor to Aviation Traders, Ltd. for the manufacture of production examples ; after the " Accountant " was abandoned, various members of the staff who had been working on it, including the flight test team, were recruited by Hawker Siddeley, thus contributing to the rapid progress that is so necessary for such a project. One significant difference between the two is, of course, that while the earlier aircraft attempted an ambitious structural efficiency, the Avro design is intended for operators with a minimum investment in maintenance facilities and to afford the easiest and simplest servicing ; the structure is fully fail-safe and the whole of it is accessible for inspection. The payload is about 10,000 lb composed flexibly of freight or up to forty-four passengers. The Series I aircraft have Rolls-Royce " Dart " R.Da.6 engines and are optimised for short stages of 200–400 miles. The Series II machines will have R.Da.7 engines ; the increased power will allow operation from higher and hotter airfields, or it can carry sufficient fuel to avoid refuelling at each stop.

Flying Display

On Monday the flying display took place in sunshine and negligible wind. It commenced with a " scramble " by four bombers, Vickers " Valiant " aircraft of No. 148 Squadron, Royal Air Force, the crews having been at readiness in the aircraft in the manner associated with fighter operation. The aircraft were supported by ground starter trolleys, allowing the engines to be started simultaneously instead of in sequence, and the four machines were off the ground within three minutes of the signal to go. This, clearly, represents a minimum response time, since the crews knew when the signal would come ; while it is conceivable that crews could stay in their stations, eating and dozing, for a day at a time, it would seem that to keep more than a third of the force at this high readiness would involve training a plurality of crews for each aircraft and undertaking more flying than is believed to be Bomber Command policy. However, it is obviously a far cheaper form of readiness than an airborne alert sustained by flight refuelling, and as such acceptable to a force with relatively many aerodromes and reliable early warning systems.

The next performer was the most interest-



(Left) The Short SC-1 research aircraft on its partly-porous steel platform ; notice the little screens in front of the jet nozzles of the lifting engines, to avoid high external pressures, and that the undercarriage has now been faired (Right) The series 2 " Prospector " ; this is a " pod-and-boom " design, and the whole rear end of the pod can be seen swung aside for loading

(Left) The development prototype of the R.A.F. "Argosy," the A.W. 660, is seen (left) with an Alvis "Saladin" armoured car and a "Saracen" armoured personnel carrier during loading assessment trials. The aircraft is in fact an A.W. 650 (polished finish) fitted with the after fuselage (matt paint) of the military transport. The aft door of the civil machine (right) now has a metal turbulator which not only suppresses buffeting but also improves the ditching qualities

ing aircraft in the display, the Short SC-1 vertical-take-off-and-landing research aircraft. This year there had been provided a concrete plinth for the machine, with a raised metal platform with, in its centre, a grille to allow the lift jets to pass through and escape under the platform. The little delta lifted off to a height of several feet, yawed through 180 deg., and moved slowly over to the runway. It then turned along the runway and, with a puff of smoke from the thrust engine, accelerated rapidly into aeroplane flight; when it flew past, it seemed incongruous that a small, slow and apparently conventional aeroplane should emit such a loud noise. The transition back to jet lift was, perhaps, even more impressive, since the aircraft, by tilting the lift engines, rejected forward speed rapidly without any change in attitude, a performance of uncanny appearance. The landing was made on the runway, the aircraft settling down with appreciable vertical velocity which was damped completely by the undercarriage; it then taxied away.

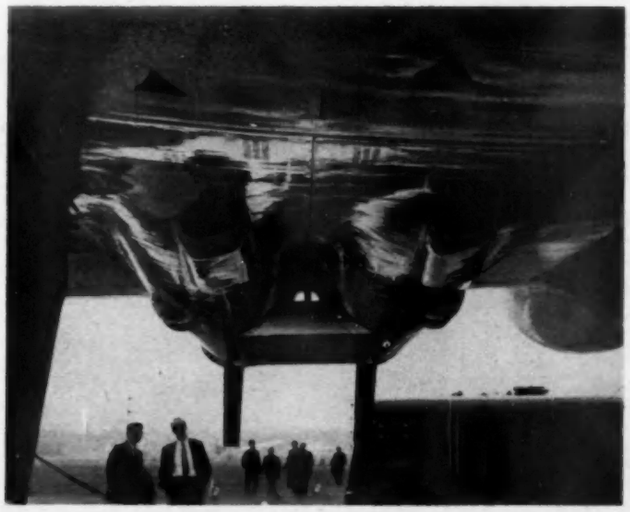
The Scottish Aviation "Twin Pioneer" made its familiar short take-off, but levelled out a few feet from the ground, cut and feathered the port engine, and climbed away on one engine. The Handley Page "Herald" taxied out with the port engine stopped in order to embark thirty soldiers of an airborne unit; having proved itself to be loaded, it then gave an objective indication of its short runway ability by both lifting off and setting down between strings of flags across the runway, 600 yards apart, at a height of two or three feet. It may, perhaps, be repeated at this stage that the "Herald" did not have a favourable wind for this feat, and added that this is the only demonstration of flying performance that we have witnessed at these displays that did not rely upon subjective assessment.

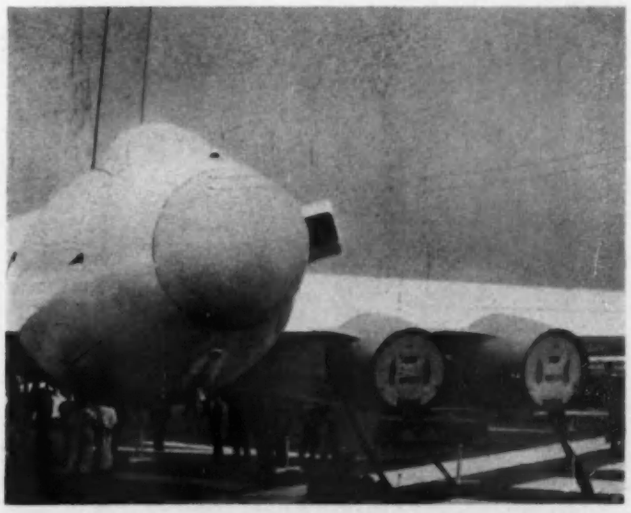
A new and more powerful version of the Hunting "Jet Provost," the T. Mark 4 with a 2500 lb thrust "Viper" A.S.V. II engine, flew; the increased thrust adds nearly 100 m.p.h. to the maximum speed, raising it to 425 m.p.h., and gives much reduced time to height, rendering it far more economic for use with pupils who have passed beyond the primary stage. The demonstrator was put into a spin above the aerodrome; it spun quite slowly in a very steep attitude, and came out into a straight dive.

For the first time, a Lancashire Aircraft (erstwhile Edgar Percival) "Prospector" took part in the display, a series 2 machine with a 360 h.p. "Cheetah" X engine; it was fitted with an Agavenco "Vari Pitch" windmill pump and sets of sprayers below the wing, with which it laid a cloud of water droplets along the runway. It may perhaps be interpolated that the series 1 machine, which is in widespread use for a great variety of duties, appeared this year in the static exhibition; it has a Lycoming GO-480 engine.

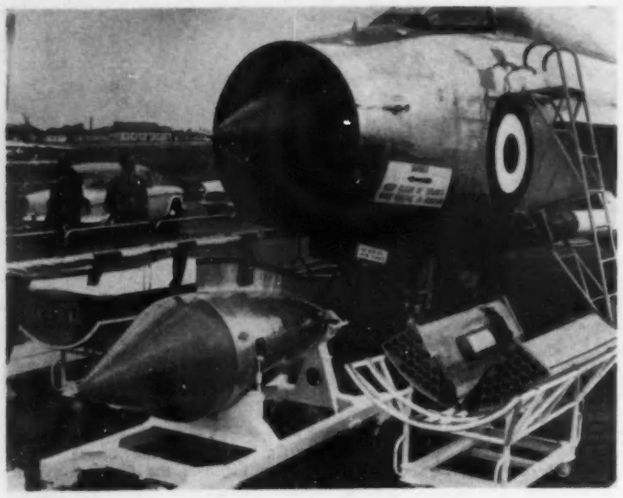
The Vickers "Vanguard" was demonstrated; one detail of its performance which might not have been expected was that the compound engines, Rolls-Royce "Tyne" turbo-props, smoked consistently under load. These engines, it will be recalled, have not yet attained an approved overhaul life, but it is expected that at least some B.E.A. services will be flown with the "Vanguard" later this year.

All the rotary wing aircraft were entered by Westland Aircraft, Ltd., and flew at the same time. They were all equipped with shaft power turbines, this conformity with current Sikorsky practice having been achieved by omitting any S-51 derivative, withdrawing the (Fairey) "Rotodyne," and converting the "Skeeter" to accommodate a Blackburn-Turboméca "Turmo" athwartships in place of the "Gipsy." The two P.531 helicopters were a civil "Wasp" and a military "Sprite"; a "Turmo" powered one of them, although the two-stage version, the A.129 or "Nimbus," would normally be fitted, and the other one had a D.H. "Gnome" which, if it may be added with causing confusion, is a General Electric T-58 built under licence. The prototype "Westminster" appeared with its girder fuselage enclosed in a streamline fairing.





The Vulcan B. Mk.2 was exhibited with some external modifications: the starboard jet pipe fairings were partly floored over, and the after fuselage enlarged to carry electronic equipment



This collection of equipment for the "Lightning" shows the "Airpass" radar that forms the intake centre body and the launchers for unguided rockets that are needed when pursuit interceptions cannot be achieved.

The Avro 748 demonstration was chiefly notable for a landing which was completed, wheels stopped rolling, in a very small fraction of the runway. This maker's other representative, the "Vulcan" Mk. II, now has no braking parachute, so its landing roll took it far from the spectators; the rear of the fuselage has now been enlarged, apparently to house electromagnetic equipment, reputedly for counter-measures. On the starboard side this aircraft had been fitted with a flat skin tangential to the two fairings of the jet pipes, starting roughly halfway back and extending to the trailing edge; a large aperture in the inclined face joining the front of the panel to the fairings allows air to flow over its upper surface, and it is supported against pressure differentials by a partition from its centre up to the wing between the fairings. It seems hardly likely that such a modification would be fitted at one side purely for purposes of assessment, so it may be speculated that it is to partially cancel some asymmetry of the air flow which is induced by the ventral fin of a "Blue Steel" when it is folded to port for take-off and landing. It may be recalled that at the last display one of the four Bristol Siddeley "Olympus" engines had been inhibited from smoking; this modification has apparently proved undesirable, for all four engines now smoked heavily.

Two examples of the Blackburn N.A.39 "Buccaneer" low-level strike aircraft performed; one flew over with the doors of the stores bay rolled back, showing that the bay is quite shallow, defined above as well as below by circular arcs, and seemingly stopping well below the wing spars. Again this year, it did not appear that the boundary layer control (by blowing from slots) that it is a feature of this machine resulted in an approach speed lower than that of the other military aircraft.

Probably the fastest run in the flying display was executed by the English Electric "Lightning" T.4 two-seater; at speed there was a cloud of condensation over the canopy, such as is usually seen in the low-pressure zone over the wings, suggesting that the widened cross section of the side-by-side cockpit has departed from the compatibility with transonic area rule that marked the fighter version. This machine is, of course, not thrust limited, and an increase in the drag at speeds near sonic would affect only the acceleration ability. Four single-seaters of the first Royal Air Force "Lightning" squadron, No. 74, flew past in tight formation.

On Monday there took off an Avro "Shackleton" of No. 201 Squadron, Royal Air Force, which, it is intended, will land again during Tuesday's display, having been airborne about twenty-two hours. Similarly, another aircraft will take off on Tuesday and return on Wednesday. Each aircraft is, it is understood, participating in an excercise and stand-by aircraft are kept at Farnborough in case of unserviceability.

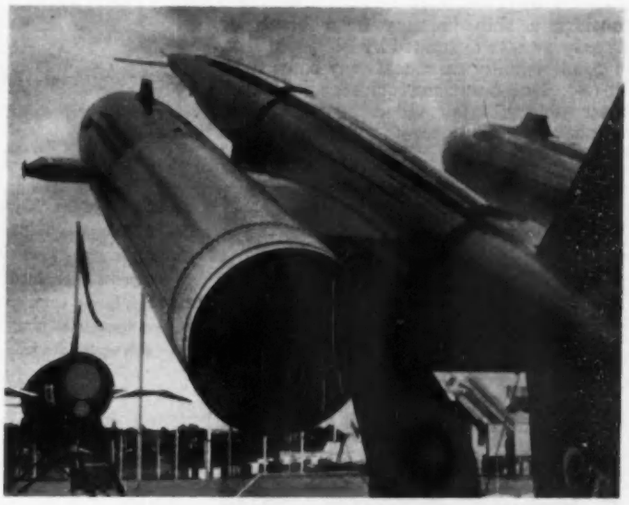
The flying display was concluded by the all-black Hawker "Hunter" aircraft of No. 111 Squadron, Royal Air Force; eighteen machines, led by a two-seater, took off in groups of five, four, five and four (to avoid later aircraft aspiring the exhaust of earlier) and executed a loop in formation. The squadron then divided into halves for a routine of loops and slow rolls with changes of formation, so that at all times some aircraft were visible to the spectators. The finale was a loop by the whole squadron in a formation called "pterodactyl"; the formation comprises a filled-in triangle or delta of aircraft, point first, with the "trailing edge" having the shape of a cusp to represent the way the reptile's skin stretched between body and fore limbs.

To put the display into perspective, it may be mentioned that it differed this year from previous editions in having no participation by the Royal Navy, which in recent years has sought to introduce novelty to the events, and that this year there was no demonstration of rocket propulsion, either for zero launching, helicopter boosting, or supplementing turbo-jet propulsion.

Missiles

Considerably more could be learnt in the exhibition about various weapons systems. There was to be seen at close quarters an Avro "Blue Steel"; this was finished matt black, in contrast to those previously seen, which have matched the radiation-resisting white of the "V"-bombers. The dimensions of the vehicle are given as length, 35ft, span, 13ft, and height 9ft 9½in. The general appearance of the vehicle is familiar; our photograph shows some details, such as the blunt trailing edges of the tail surfaces. Various vents for hydrogen peroxide are marked with warning signs, and the two chambers of the "Stentor" engine are closed by blanks bearing instructions that

The "Belvedere" (Bristol 192) helicopter appeared with two different shapes and locations for the fixed aerofoils. Notice that the vertical fin is markedly asymmetrical

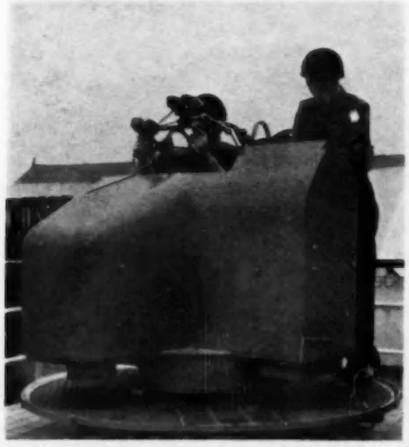


(Left) The "Blue Steel" has blunt trailing edges for rudders, elevons, and fixed surfaces. The "Stentor" engine is blanked off until it is fired (Right) The Nord C.T.41 supersonic target drone is of canard configuration, and is controlled by oscillating spoilers on the stubs of wing outside the ramjets

they be not removed before flight ; this is to prevent cold air circulating in the nozzles and cooling the engine unnecessarily.

Next to the "Blue Steel," Sir W. G. Armstrong Whitworth, Ltd., exhibits a Nord CT-41 target drone, which it has a licence to service in this country. This aircraft is capable of climbing to 65,000ft at Mach 2 in eighty seconds, has an endurance of fourteen minutes, and can range between Mach 1·5 and 2·5. The two great Nord 625 ramjets should render it an easy target for the infra-red "Firestreak," which has yet to be evaluated against a supersonic target. Our illustration shows the canard configuration and the spoilers on the winglets outside the engines ; the airframe is 32ft 2in long and the span is but 12ft 3in.

An elaborate and instructive display featured the short "Seacat" short-range ship-to-air missile. We illustrate the two main installations, the launcher and the control unit. The transport container, of steel tubes and glass fibre reinforced plastic, is removed when a round is loaded on the launcher, and

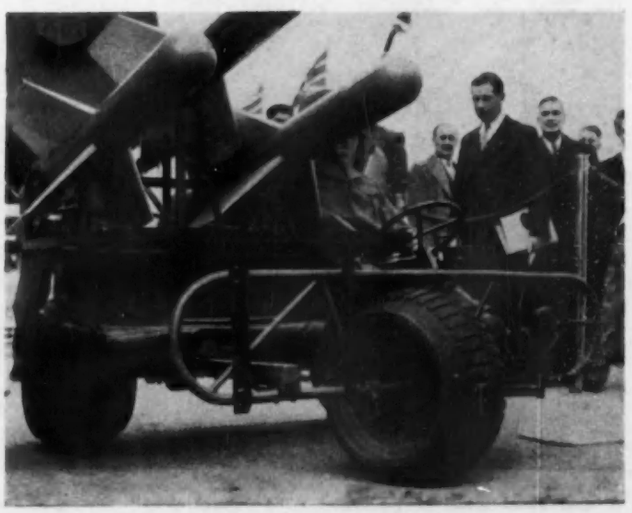


The "Seacat" ship-to-air missile system is controlled from a two-man turret, the operator watching the missile through binoculars, composing a collision course, and controlling with a thumb joystick in his right hand

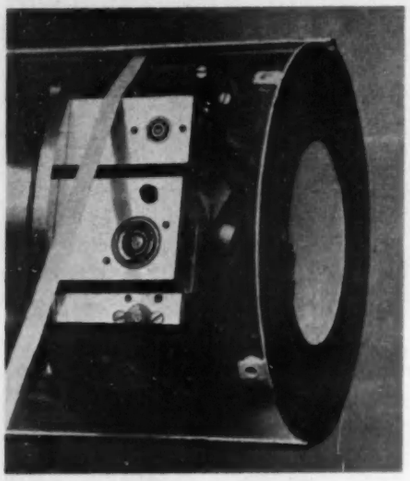
in action a platic cover would remain in place over the missile ; when the round is fired it tears its way through the plastic. The launcher includes a range-finding "radar." The launcher, when in action, at all times faces in the same direction as the optical sights of the controller. The control system employs two men ; one stands on a circular platform and rotates the whole turret to face in the desired direction, and has a desk with missile selectors, "Fire" switch, and a dial giving the range of the target. The second sits behind the binocular sights, which have limited travel in azimuth and elevation, and holds two hand grips ; one contains a trigger which, when closed, activates the "Fire" switch, and is clasped when the sights are on a target, while the other carries a joystick, moved by the layer's thumb, which selects the commands to be transmitted to the missile, and also a small circular aerial radiating the command signals. Thus it will be seen that the weapon contradicts our anticipations of twelve months ago and does in fact use command guidance ; however, no claim is made that a control loop containing a human operator has demonstrated the capability of intercepting a moving target. The system as now revealed appears to have several disadvantages, starting with one belonging to beam-riding systems such as the longer-range "Seaslug," that a second target cannot be acquired until the missile fired at the first has completed its flight ; the first crew member may be free to look for a second enemy, but he would probably not be allowed to turn the control turret while the guidance member was commanding a round. An obvious disadvantage is the need for the target to be visible ; contemporary fighter-bombers usually "see" by radar for terrain avoidance, the pilot's visibility being quite inadequate at high speeds, and there is no reason to

The launcher for the "Seacat" carries four missiles and a range-finding equipment ; the missiles are loaded on in their transport cases and, at sea, protected by plastic inner cases

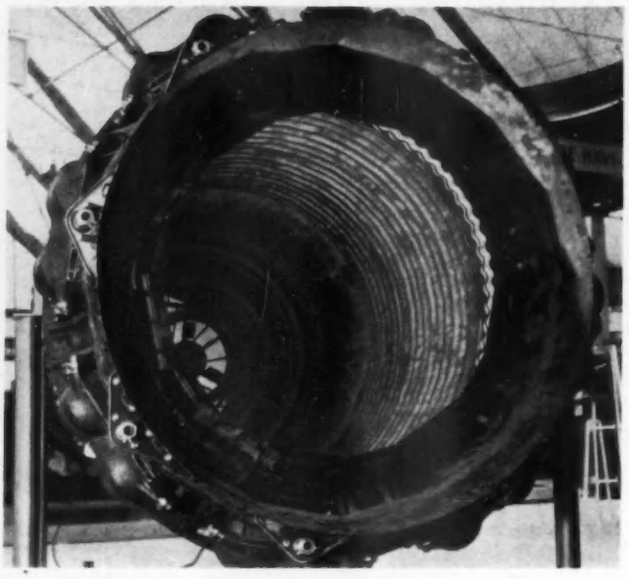
The Pye anti-tank weapon is seen here installed on a zero-length launcher carried into action by an air-portable go-anywhere F.N. three-wheeler



consider a ship immune from bomb or torpedo attacks in limited visibility—in fact, in good visibility the threat may come from air-to-surface command guided missiles. A lesser objection is that it is, apparently, necessary for the operator to look at the range meter to the exclusion of the target



The jet deflection system of the Pye missile is stabilised in roll and rotates around the motor on ball bearings acting on rollers. The nozzle itself is graphite



Afterburner of the "Gyron Junior" for the T.188 in the convergent position; to economise in production, the rings in the convergent section have been given a corrugated shape

and to estimate the range rate, whereas the choice of best time to fire would seem to be highly sensitive to the height and course of the target.

The unconventional Pye anti-tank weapon is also illustrated. It will be recalled that this missile is controlled by deflecting the jet of the sustainer motor. There is but one jet, and so no control in roll is available. The vehicle is therefore allowed to roll, and the jet deflection system is stabilised in roll by means of a gyroscope. Our illustration shows the deflection assembly, which runs around the rear of the sustainer on rollers in the form of small ball bearings. The nozzle itself is, apparently, of graphite, and is deflected by segmental racks engaging gear wheels driven by electric motors. The control commands reach the round along a trailing wire, apparently but a single strand, which is coiled quite simply about an aluminium spool and led off down the inside of a glass-fibre cone slanted towards the exit hole. The missile, which is 60in long with a diameter of 6in and a span of 24in, weighs approximately 80 lb.

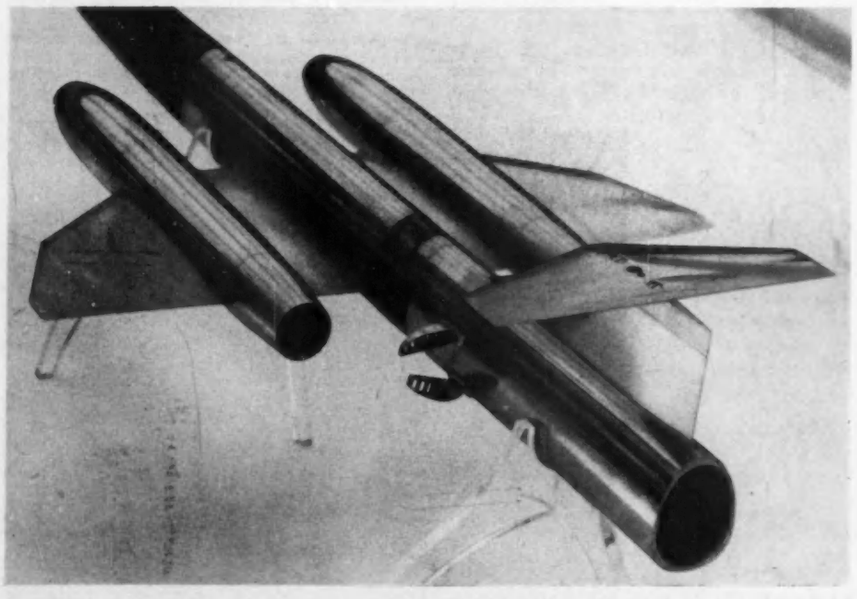
The wire starts from a ground control unit weighing about 20 lb. The signals originated by controller's joystick are "shaped" in the control unit, and it is, as last year, claimed that very little training on a simulator endows an operator with efficiency. The missile is observed through binoculars, and there is under development a sight with which a change in magnifying power can be made without the operator losing sight of the target.

One great disadvantage of the wire-guided weapons is that they must be controlled from a point of vantage, which is in all probability not a good site for storing them. The Pye system counters this disadvantage by exploiting the go-anywhere abilities and low silhouette of the Fabrique Nationale A.S.24 *véhicule aéroporté*, which is built under Straussler licence and has 22in by 12in "Lypsoid" tyres made by Metzeler. This vehicle, with a 243 c.c. aircooled twin two-stroke of 15 h.p., has a maximum speed of 35 m.p.h., and when grossing 10 cwt. can climb (slowly) an 80 per cent gradient with tractive effort to spare; it weighs only 3½ cwt and as many as twelve can be air-dropped from a Fairchild C-119 "Packet," each having a pair of personnel parachutes.

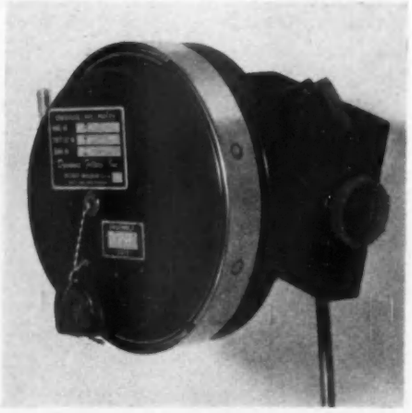
With the exception the Fairey "Firestreak," all the British guided missiles that have entered production were on show; particularly prominent was the English Electric "Thunderbird," the 36th A.A.(G.W) Regiment Royal Artillery deploying a battery of four launchers and a field assembly and test point.

Static Exhibition

In the exhibition tent some of the aircraft that are not yet to be seen are displayed in model form, and one example is the Bristol T.188, of which we illustrate a steel wind tunnel model; this is of interest as showing the air brakes. The complete tail plane of the machine, mounted on a dummy fin, was also on show. The engine of the T.188, the D.H.

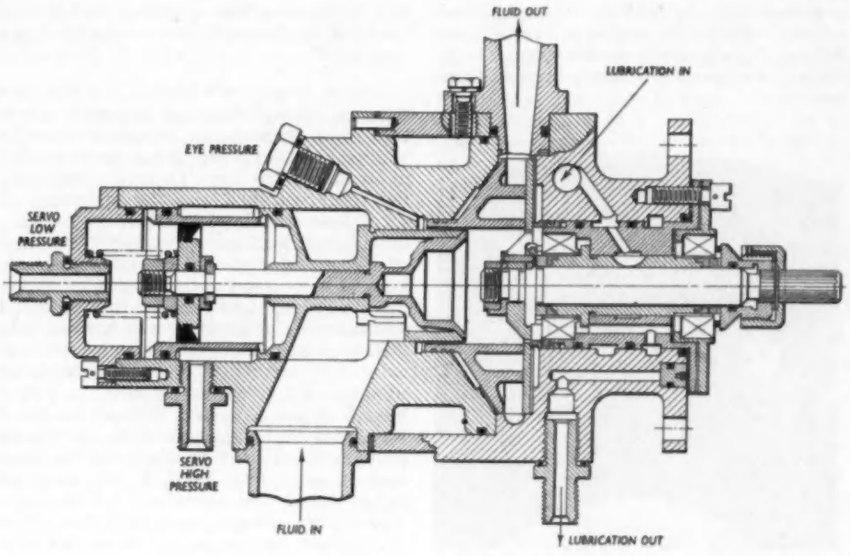


A wind tunnel model of the Bristol T.188 research aircraft, showing air brakes in the extended position

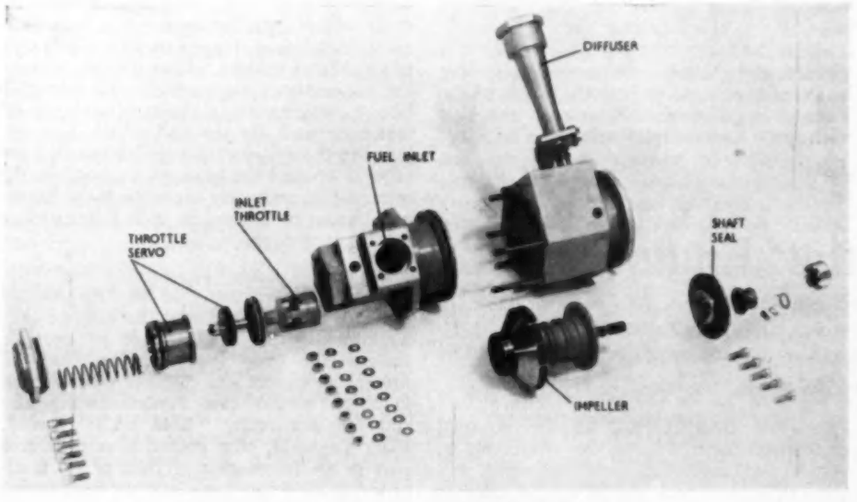


A centrifugal fuel purifier which is energised by shaft drive from the engine

"Gyron Junior" D.G.J. 10, is also illustrated; it will be seen that the variable nozzle is quite simple, having alternative convergent or convergent-divergent forms—there is no indication that the nozzle has any intermediate positions. The afterburner, which can just be discerned, runs at 2000 deg. K and raises the thrust from 10,000 lb to 14,000 lb; at Mach numbers around 2·5 the thrust



Section through "vapour core" pump with throttle closed



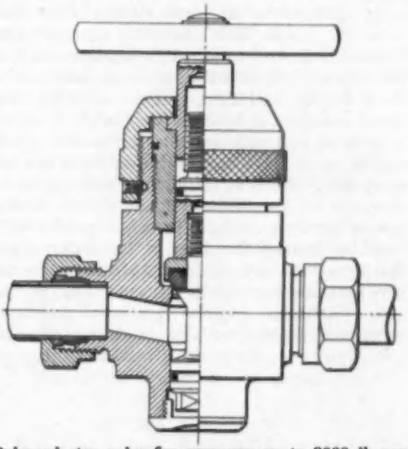
"Vapour core" pump dismantled

increase due to reheat is quoted as 200 per cent suggesting that turbine blade temperature limitations are restricting the engine output considerably at this speed. This does not necessarily indicate that the engine will thrust the T.188 to such speeds, photographs of the mock-up having shown intakes suggesting design speeds less than Mach 2.

Also on the de Havilland section of the Hawker Siddeley Aviation stand was the mechanically driven centrifugal oil purifier illustrated, a product of Dynamic Filters Inc., Detroit, Michigan, which is to be incorporated on the "Gnome" to clean the fuel. At 4,200 r.p.m. input, the rotor acceleration fluid rises to 688 *g*, and it is claimed that impurities are reduced to 40 grains in 1000 gallons.

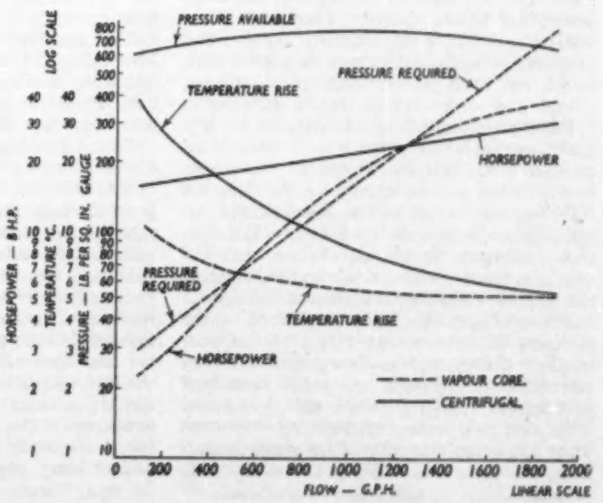
A pump for use where a wide range of outputs is necessary is shown by Dowty Fuel Systems, Ltd. The existing solutions were deemed unsatisfactory mainly on the grounds of high power consumption, and hence high heat input to the fluid, at low flows. To control either the speed or displacement of the pump, as by variable speed drive or use of a swashplate pump, involves cost and weight penalties, while a simple centrifugal pump driven by an air turbine may present control problems—for instance, overspeeding if no fluid is present. A fuel pump with a good part load efficiency would, it is pointed out, have the virtue of not filling up the heat sink represented by cold fuel on a supersonic aircraft.

The "vapour core" pump is in effect a centrifugal pump with a throttled intake. The throttle valve has a cylindrical restriction, so that no fluid is delivered to the centre of the impeller—hence the term "vapour core." The arrangement of the pump is shown in the accompanying drawing; the hydraulic servo operating the throttle is so arranged that increase in servo pressure reduces the flow, so that the servo is inherently stable with reference to pump delivery. A dismantled pump can be seen in another illustration; conspicuous is the diffuser, in which 40 per cent of the pressure rise occurs.



Balanced stop valve for pressures up to 8000 lb per square inch

It will be observed that, even though this is a fuel pump, it is designed not to be self-lubricating, so that the pump can be run continuously and delivery stopped merely by shutting the throttle. Several thousand hours running have been carried out on pumps from 3in to 7in impeller diameter and speeds 10,000 r.p.m. to 30,000 r.p.m. The chart reproduced here shows the characteristic of one experimental pump; this example has an efficiency of 30 per cent, falling to 6 per cent at 500 g.p.h., but efficiencies of about 45 per cent are expected to be attainable. Such pumps have shown a working flow range of 100 : 1, with, at the low flow end, an efficiency four times that of



Characteristics of an experimental "vapour core" pump

a centrifugal pump. The principle is expected to be applicable only to pumps delivering over 500 gallons per hour.

Another hydraulic accessory is a balanced stop valve shown by British Ermeto Corporation, Ltd.; this valve is intended for pressures up to 8000 lb per square inch or, if used with gas, 5000 lb per square inch. Sealing is by " O " rings, and the screw threads, it will be seen on our drawing, are outside the seals. The property of balance is derived from the valve being basically a constant-diameter spool valve, so that the volume of the bobbin moving out of the pressure volume is equal to that moving in, but to more easily suppress leakage the central sealing annulus has been given a conical seat of nylon which is replaceable. Valves with Ermeto fittings, like that illustrated, are made for pipe sizes ¼in to 1¼in, and with B.S.P. female ends over the range ⅜in to 1¼in.

A refinement of tyre design that has hitherto been little known outside the United States of America is displayed by the Goodyear Tyre and Rubber Company ; this is sidewall inflation. The conventional valve involves a hole in the highly stressed wheel rim and may impose a reduction in the available swept area of the brake discs—it should be borne in mind that Goodyear, in contrast to the better known British brake manufacturers, designs for maximum swept area by driving the discs at the outer edge. But once the separate inner tube is discarded it is reasonless to retain inflation through the rim. Goodyear tyres with sidewall inflation have withstood crushing tests at inflation pressures up to 385 lb per square inch without valve failure, and have been adopted by such large quantity producers as Cessna Aircraft Company and Beech Aircraft Corporation.

Sidewall valve in aircraft tyre

The sidewall valve has the appearance of a blue dot about ⅜in diameter flush with the sidewall ; to check or alter the tyre pressure, a needle incorporating a conventional valve is greased and pushed into the sidewall valve as far as it will go. Where the whole of the sidewall is not accessible, as on a machine with spats, a plurality of valves can be fitted.

(To be continued)

Statics and the Engineer

It was in the belief that too seldom is statics given a chance to show not only its grace, but its practical liveliness and power, that Sir Alfred Pugsley chose the subject of this address delivered to Section G (Engineering) of the British Association for the Advancement of Science on September 1, 1960*

THE basic ideas of statics, which were first developed during the fifteenth and sixteenth centuries in such cultured cities as Venice and Rome, arose from discussions among Court Mathematicians and Physicians about the principles of operation behind the common building tools of their time—levers, inclined planes and wedges. The masons, engineers and architects of the day—and there was then little distinction between them—had been long accustomed to the use of these implements and so naturally gave little attention to the logic or scientific principles behind them. There was thus started a dichotomy between theory and practice, between statics and its application, which has been present with us, in varying degree and with varying results, ever since.

This was interestingly illustrated by the problem that arose when it was discovered, around 1742, that the Dome of St. Peter's was showing serious cracks. Pope Benedict XIV called in three mathematicians to examine and report on the matter. This they did, and came to the conclusion that the two iron tie rings placed around the base of the dome when it was erected had been overloaded and should be reinforced by the addition of three further rings. In support of their theory and proposed remedy, they submitted calculations using the then new principle of virtual displacements, but somewhat confused their argument by erroneous ideas about the elasticity of the rings. Apart from this error, typical of the notional difficulties then still to be overcome in statics and elasticity, their argument was generally sound and surprisingly modern in that it allowed for a factor of safety of 2 in assessing the total strength required of the new tie rings !

However, the novelty of this approach to dome construction met with resistance from practical men. " If it is possible," they said, " to design and build St. Peter's dome without mathematics, and especially without the new fangled mechanics of our time, it will also be possible to restore it without the aid of mathematicians and mathematics—Michelangelo knew no mathematics and yet was able to build the dome." In spite of this, within a year the architect Vanvitelli fitted five new tie rings and all was well.

This episode is something of a landmark in the history of applied statics : in a field of construction dominated by tradition and practical skill, the strength and stability of a structure was subjected, for the first time on a large scale and in the public eye, to statical analysis. One wonders how it was that the Pope came to appeal to his three mathematicians ; perhaps it arose in part from a fashion in high places at the time. Bell, in his *Development of Mathematics*, remarks on the leading mathematicians of the eighteenth century as being supported by the Kings and Emperors of the time with an eye to the need for mathematics in the advancement of civil and military engineering. " These rulers," he says, " were clear sighted enough to see that the simplest way of getting mathematics out of a mathematician is to pay his living expenses."

It is of interest to examine, starting from this story of St. Peter's, the changing climate between mathematicians interested in statics and the like, and practical engineers engaged in construction. The eighteenth century, in this country, closed with the beginnings of the industrial revolution, when the engineer turned from his traditional materials to new ones like cast iron and wrought iron. As a result he was forced to think more about, first the strength and then the stiffness of his structures, and in the absence of any adequate theory (at least as known to him) he turned naturally to experiment, testing his beams and columns, and even his bridges, to assure himself of their adequacy. But such assurance was not enough ; he wanted to understand in more detail just how his structures managed to carry their loads, if only so as to design better and more economical ones. And so he *himself* approached the mathematicians of his day, instead of, as in former centuries, having them imposed upon his activities from above. In suchwise came Gilbert, a President of the Royal Society, to analyse with Telford the strength of a suspension bridge cable, and Hodgkinson to study with Robert Stephenson the behaviour of tubular beams, preparatory to the design of the Menai bridges. Thus the first half of the last century saw classical statics extended into the engineering domain of strength of materials, and, by the end of the century, into the theory of structures. Hooke's Law of 1678 became the basis of a whole theory of elasticity, and early experiments on beams and trusses blossomed in such structures as the Forth Bridge.

But all this, it must be admitted, was at the top level. Brunel could do his own calculations for the Clifton Bridge, Benjamin Baker could analyse a whole range of possible designs for long span bridges, but the ordinary architect and engineer was for long in much weaker case mathematically and still did not really " hold with " theory. Even Tredgold, who played a considerable part in the foundation in 1818 of the Institution of Civil Engineers and the furtherance of engineering science, could, on occasion, remark that " the stability of a building is inversely proportional to the science of the builder." A hundred years later, in the 1920's, when I first worked in an engineering drawing office, it was still natural to be advised by the engineer in charge to " keep your degree dark, and at all costs avoid letting out that it was an honours degree". But I have, it seems, lived to see a more enlightened age, when engineering graduates have overrun almost every branch of civil engineering, particularly those where statics, in its classical or more developed forms, can play a useful part. The old dichotomy has largely broken down : but this is not so much, I think, because mathematicians and engineers now speak the same language : in the sense that language expresses in part habits of thought, they still, and rightly, do not. What has happened is that mathematicians—in modern terminology, applied mathematicians—are now seldom interested in statics, which seems dead to them. They have moved on to other fields—in this generation mostly to fluid mechanics—and have left statics to the mercy of engineers. As a result, in this century, statics has been blossoming in a new and rather strange, if sometimes muddled way, full of interest to the engineer, but ignored or viewed with some disdain by the mathematician. I propose in what follows

*Department of Civil Engineering, University of Bristol.

to concentrate mainly on this new blossoming, using some modern structural problems by way of illustration.

Friction

But first let us look at an apparently more humble illustration. Nearly every schoolboy learns the classical " laws of friction " in relation to motion, or lack of motion, on an inclined plane. And those of them who happen to test these laws by elementary experiment will have had the perhaps unexpected experience of finding that the so-called laws are by no means precise and sometimes erroneous. Such experience is, of course, the very best of introductions to both the nature of science and the problems of engineering.

Putting aside the effects of lubrication as more appropriate to dynamics than statics, let us consider the problem of friction between dry surfaces. So long as scientists and engineers thought of the two bodies concerned as rigid bodies with smooth surfaces, no physical understanding of the basis of friction or improvement upon the old classical laws was possible. And each generation of schoolboys, after a few experiments, took the so-called laws—and perhaps by inference the whole of statics as presented to him by his master—with a pinch of salt.

It has taken twenty to thirty years' work in this century to break this impasse, to set aside here the notional difficulties of classcial mechanics and start to think of friction as a problem in the strength and elasticity of materials. Once the touching surfaces were thought of not as rigid and smooth but as inevitably somewhat rough, like the surface of the earth or the moon in miniature, with protuberances which kept the bodies apart so that only a small proportion of the total surface actually touched ; once it was realised that these touching asperities were bent, sheared, or otherwise deformed and even ploughed up by any effort at relative translation, a new light was shed on dry friction. At once the broad reasons for the tendency of most materials to behave somewhat in the manner of the old laws, and the reasons for their departures from these laws under certain conditions, began to become apparent. So far from the friction between two bodies being independent of their area of contact, the true contact area was seen to increase, due to local yielding at a steady stress intensity, with the force between the surfaces ; and the frictional resistance, established mainly by the shearing resistance of the touching and interlocking " peaks " on the surfaces, naturally tended to increase with the amount of true contact. The schoolboy who always wanted to argue that the friction must increase with the intensity of pressure between the surfaces was wrong in his terms but was nevertheless barking up the right tree.

The discovery of the real nature of friction between dry metal surfaces—due mainly to Bowden and his colleagues at Cambridge—of course derived not only from the change of viewpoint I have emphasised, but also from the resourceful use of modern techniques for the examination of metal surfaces and for the measurement of these areas of contact. But the change of outlook was fundamental to this successful re-exploration of the old laws of friction ; and, as I hope to show in further examples, it is the overcoming of notional barriers that in statics, as in so many sciences, has led to substantial advances.

Frameworks

Most sixth form schoolboys with a scientific bias, and all engineers, gain some familiarity with the way in which a frame, such as a roof truss or bridge girder of lattice type, is analysed for design purposes. The frame is treated as a structure with all its members in one plane and the joints where the members intersect are imagined to be smoothly pinned. The forces acting on the frame, whether due to gravity or wind, are then estimated and treated as concentrated at the joints. For the set of external forces so determined it is then easy, though somewhat lengthy, to calculate the internal forces —the pushes and pulls—in all the members of the frame. If the structure is to withstand the external forces, each joint must be in equilibrium ; thus the forces acting at a joint—the external ones and the internal actions in the members intersecting there—can be calculated graphically or analytically by the application of the classical " polygon of forces " rule of statics.

This approach to the design of a plane frame, which started in this country early last century, has since been developed into systematic graphical and analytical processes that are still widely used in design to-day. But there were within it two snags that have over the years caused heart searchings among engineers and drawn occasional contributions from mathematicians. Both relate to the arrangement of the members in the structure, though in different ways.

If we examine an ordinary railway bridge truss, we will find commonly that the members are arranged in a repeated pattern leaving open triangular spaces. Thus the top and bottom booms of the truss may be parallel and the members joining them be alternately vertical and inclined, to form what is called an N truss. This sort of construction, if truly pin-jointed, leads to what is known as a just-stiff frame ; that is, if you take any one member away, the frame loses its stiffness and becomes a mechanism with one degree of freedom and so will collapse under any external loading tending to excite such motion. On the other hand, if you add a member, as for example a supplementary diagonal member, the structure remains stiff, but what now happens is that one can no longer analyse it by the principles of classical statics alone. The condition that all the joints must be individually in equilibrium gives insufficient equations for the calculation of the internal loads in all the members. The structure is then said to have a " redundant " member ; and some practical structures have many such.

There is another form of redundancy common among frames : that due to external constraint. If we return to our railway bridge, we shall commonly find—at least in the older bridges—that one end of the truss is supported by a heavy pinned joint, while the other rests on rollers to allow, for example, freedom for thermal expansion longitudinally. This arrangement, however, has other effects. At the pin, if smooth, the support reaction can have two components, as vertical and horizontal ; at the rollers, if frictionless, only one reaction (vertical) is possible. Thus when we come to consider the equilibrium of the truss as a whole, we have three unknown reactions to determine ; for this, we have the three equations of equilibrium, corresponding to the balance of forces in the vertical and horizontal directions and of moments in the plane of the truss. But had we pinned both ends of the truss we should have had more unknowns than we could determine in this way by classical statics ; we should have had a redundant reaction.

The calculation of such redundant actions, whether internal or at the supports, has been a problem and a battleground for engineers over the past 100 years. If we assume that we want to study the structure under elastic conditions, that is, loading conditions such that all the members remain elastic and return to their original configuration on removal of the loading, then the problem is one essentially of arguing that not only is every joint in equilibrium but that the forces in its members produce extensions and shortenings therein that are themselves consistent with the continuity of the frame as a whole and with its supports. Indeed, as was first pointed out by Clebsch in his famous book on elasticity in 1862, the whole problem can be transformed by regarding it not as one directed towards the solution of unknown forces, but as one seeking the component displacements of the joints. In these terms there are always as many equations available as there are unknowns.

This sweeping generalisation by Clebsch was, however, largely unknown in England, and English engineers for long dealt with redundant structures either by avoiding them in favour of statically determinate ones or by the direct matching of loads and deflections in the manner systematised by Maxwell (1864) and Mohr (1874).

By the time I was an undergraduate a new approach was becoming fashionable. Back in 1873 Castigliano had shown that if U is the strain energy stored in a frame due to a given system of forces, and P_1, P_2 . . . are the forces in the redundant members, then these unknown forces can be determined by the linear simultaneous equations

$$\frac{\partial U}{\partial P_1}=\frac{\partial U}{\partial P_2}=\frac{\partial U}{\partial P_3}=\ldots=0,$$

and he enunciated this finding as a " Principle of Least Work". When this work was first translated by E. S. Andrews in 1919, it started at once a new fashion and a new problem. Energy methods had at last entered the realm of structures in the hands, not of the mathematicians, but of engineers. And the latter first tended to swallow Castigliano's idea of least work as a natural principle—that elastic structures always so managed their affairs as to resist a given system of loading with a minimum of work, i.e. as lazily as possible. Some were more cautious and sought other physical " explanations " ; of these the only one that was in itself completely sound and gained some popularity was that due to Southwell (1923), who pointed out that any redundant frame was liable to self straining during erection owing to the forcible insertion of bars or constraints of slightly incorrect geometry, and that Castigliano's theorem effectively expressed the physical condition that the total strain energy in a structure assumes a minimum value when there is no self strain.

A modern theoretical physicist, accustomed to dealing with entities having no direct physical meaning, would be amused if he knew of these " explanation " difficulties among engineers, particularly when he learnt the outcome of the further study of Castigliano's theorem. It has long been known that the differential equations resulting from Castigliano's energy approach were just the deflection " matching " equations necessary to supplement the equilibrium equations that were otherwise inadequate in number. Only in the last decade has it been realised that the linearity of the frame problem masked the fact that Castigliano should for generality have dealt, not with the strain energy (U) of the problem, but with what Engesser called the " complementary energy " (C) and that

it was this, not U, that should be differentiated to give Castigliano's equations in generalised form, thus :

$$\frac{\partial C}{\partial P_1} = \frac{\partial C}{\partial P_2} = \frac{\partial C}{\partial P_3} = \ldots = 0.$$

What would delight a physicist of to-day would be the knowledge that even civil engineers have thus to confess that they have been, and are still, using an "energy" that has no direct physical meaning, for C can only be expressed as $\int y.dP$, where y is a deflection under a load P.

I have said that over the last century there have been in the early theory of frames two snags to worry engineers ; one is the question of redundancies on which I have already touched ; the other is the question of how best to arrange the members from an economy standpoint. When designing a frame we have, in general, to transmit a load or system of loads from given points to given supports, and one would like to know how to do this with economy of material. We can see the immediate response of engineers to this problem in the variety of frame arrangements used for almost the same job : the many different forms of roof trusses and bridge trusses developed last century all point to practical efforts towards the solution of this "best frame" problem. A guiding factor has been the idea that compression members, naturally liable to bow, should be kept as short as possible, and that tension members, free from this trouble and for which specially high strength materials (like wire) are available, should be the longer and more numerous. A succession of practical rules have been invented to aid economical design here; perhaps the best known last century was the rule that said economy in a girder was achieved by ensuring that, at the finish, the weight of its upper and lower booms was closely the same as the weight of its web members (their verticals and diagonals in an N truss). In this century, designers are well aware that a bridge girder excessively deep

$$\left(\frac{\text{Span}}{\text{Depth}} < 5\right) \text{or excessively shallow} \left(\frac{\text{Span}}{\text{Depth}} > 15\right)$$

will be uneconomic. Only in recent years has a more scientific return to this problem appeared. In 1958, H. L. Cox noticed that a theorem of Michell, based on an earlier one by Clerk Maxwell, could be used constructively to provide, for a given load and support system, a "best frame" arrangement. This at least is the theoretical position, though the actual process is difficult and has only been worked out in a few cases. The results look strange to the framework designer, at least until he remembers his predisposition to tension members rather than compression members. It seems, in the long run, as if the spider is the ideal frame designer ; he uses the supports and the structure behind them (the branches of the bush) to provide his compression needs, and builds his web frame with "fans" of tension members. But the method so far developed on these lines lacks provision for other practical factors ; in general, for example, we have not only a given set of loads and supports, but are restricted to a given space within which to construct our structure.

I have so far been discussing the statics of frames as though frames were restricted to plane frames ; whereas space frames are sometimes used and present all the problems of frameworks *par excellence*. By a space frame I do not mean here the kind of frame in three dimensions that is constructed by an assembly of plane frames, as in the triangular framework of a radio mast or the rectangular frame of a tall building. I mean the sort of frame that is conceived as a space structure from the start and so unlikely to have more than a few of its members in any one plane. We have few examples of such structures in this country ; some domes on the Continent are proper space frames, but the best examples occurred in airship structures in Germany, England and the U.S.A. in the 1920's and 1930's. In the course of this development the engineers concerned realised how little classical statics had done for them in this ambitious field, and strove, with the help of mathematicians and geometers, to advance the theory of space frames to cope with the new practical needs. Old theorems relating to the adequacy or redundancy of plane frames had to be replaced by new ones—even now less comprehensive than one would like—for space frames. Southwell, with his flare for intriguing titles, produced new processes such as "The Device of the Separate Panel" —little known to-day—and his much more general "Relaxation" methods in the course of this work. And Roxbee Cox charmed us with his excursion into the nature of just-stiff space frames—still unsurpassed or substantially extended—"On the synthesis and analysis of simply-stiff frameworks" (1936).

Here we are at the frontiers of our knowledge of frames. No new wave of interest has arisen of sufficient intensity to push much further ahead. And at the back of the problem is the rarity of finding anyone among engineers or mathematicians who thinks naturally and constructively in three dimensions. Much was done in Germany at the end of the last century ; England and America had an airship heyday ; a new generation must take the next steps. Until that happens we seem doomed to see "plane frame" structures all about us, when many of us feel sure that structurally and aesthetically better things could be achieved.

Suspension Bridges

Bridge designers are all looking forward to the completion of the first great suspension bridge in this country—that over the Forth—and hoping with South Wales and Bristol to see the start of one over the Severn. To them, and I suspect to many schoolboys in the next generation, the large suspension bridge presents a challenge that, given the opportunity, few could resist. If statics can do any good in the world, here is something it can do with pride. The theory of the suspension chain and cable, whether viewed as a parabola or as a catenary, is something that has intrigued engineers and mathematicians for over 200 years. Most engineers, and many schoolboys, are able to discuss the mechanics of such a chain loaded only by its own weight, or by some uniformly distributed loading hung upon it. But one has only to try to determine the behaviour of such a cable under a single concentrated load to realise the real difficulties of the problem. Thus it has taken the sustained efforts of many able workers in this field to build up even an approximate theory of suspension bridges. And this has been paralleled over the last two centuries by the extension and improvement of the practice of construction.

Rankine, helped by the practice of Telford and Brunel and the model experiments of Barlow—all great names in English engineering history—produced (in 1858) the first scientific theory that made some allowance for the interaction of chain and stiffening girder appropriate to the spans (up to 200ft) of his day. But his theory, and those that followed upon it, treated such bridges essentially as elastic structures, with the cables liable to stretch and the girders liable to bend. It took the physical intuition of the designer of Brooklyn Bridge—Roebling—to realise that the weight of the bridge itself (in most bridges a nuisance) was a "good thing" that could in the limit (with large spans) do all the stiffening that was required. The great George Washington Bridge, with its eight lines of traffic over a 3500ft span, but without any stiffening girders, has for long stood as a monument to the theory that was developed out of Roebling's hunch. Here was a piece of statics that bridge engineers had forgotten about : you load a bridge at any one point, the structure "gives" a little and the load moves downwards and so loses potential energy. In most structures, this energy is stored in the structure as "strain energy"—energy in elastic form associated with stretchings, shortenings and bendings of members of the structure—that will cause the structure to spring back to its original geometry when the load is removed. But in suspension bridges (and in small unnoticed degree in some other structures) the relative inextensibility of the cables commonly forces the structure, when loaded and deflected downwards at one point, to rise at many other points. So the structure itself, instead of slightly losing potential energy by the downward movement, actually gains potential energy ; and with heavy long span bridges this gain may be substantial. Thus if you pull downwards on a suspension bridge much of the resistance is not elastic in the usual way, but is really due to gravity. This was, until quite recently, only appreciated by the few designers of the latest large bridges.

We thus have, added to the problems of the irregularly loaded catenary, the wider problems of the action of a stiffening girder and the partition of energy between the elastic and gravity potential forms : a non-linear problem in statics still worthy of engineering scientists and still calling for further improvement.

Tubes and Shells

All engineers have at some time or another been interested, at least mildly, in some problem of elastic stability. Last century, with the coming of metal construction, few could refrain from having views on the column or strut problem : on how to predict, or provide against, instability in compression. In the first half of this centry, in somewhat the same way and at least from aeronautical contacts during the wars, many engineers have become aware of the buckling problems of thin plates in compression or shear. These are all essentially, whether the material is elastic or not, problems of static stability. In contradistinction to the problems of strength and stiffness we have just been looking at in the realm of frameworks and suspension bridges—and without suggesting that these structures cannot themselves sometimes exhibit instabilities—let us turn, under our heading of tubes and shells, to some stability problems.

In the early days of higher technical education, the Central Technical College at Finsbury, with a staff including Silvanus P. Thomson and John Perry, was of high repute and became, indeed, the forerunner of Imperial College, London. The textbooks prepared by the staff at Finsbury, were, for their time, of high standard and widely used. In one of the best known of these books, Perry's *Applied Mechanics* (1897), there is a short section dealing with the problem of the tubular strut, in which the advantages to be gained by "inflating" such tubes are emphasised.

With this in mind, let us turn and look first at the problem of the thin tube (unpressurised) in compression. In the First World War

such tubes became common in aeroplane structures, and this, together with advances in methods of manufacturing these tubes—drawing, extruding, rolling and welding—led to great interest in predicting and preventing premature local buckling of the walls of such tubes when in compression. There is clearly a great advantage with such struts in using, for given length of column, as large a diameter as possible to prevent general bowing ; but when this is done, for a given cross-sectional area of metal, the tube walls may become so thin as to precipitate local buckling and crumpling in the manner of an open-ended paper tube. In 1914, Southwell investigated the theory of local buckling of this kind, examining the stability of the walls by considering the effect of a generalised small elastic sinusoidal deformation of the walls. His result, as was shown by parallel experimental work by Andrew Robertson, was of the right general form, though in practice buckling occurred at roughly one-third of the theoretical critical value. The difficulty of making at that time thin enough tubes adequately to check this theory (a wall thickness preferably less than 1/100th of the diameter was required), together with previous experience of the effects of initial irregularities on solid strut behaviour, gave rise to the idea that this major numerical difference between theory and experiment arose from the inevitable departures in a real tube from true cylindrical form. And so the matter stood until fairly recently.

During the last war, however, when aeroplanes no longer used circular tubes so much as curved metal plates in compression, the same sort of discrepancies between test and theory again arose repeatedly, and Von Kármán in the U.S.A., and Leggett here, opened up a new approach. They argued that, although initial irregularities might be partly responsible, the main cause might be found in the inadequacies of the linear theory used by Southwell for what might be essentially a non-linear problem. It had long been observed, for instance, that the walls of thin tubes, when buckling, moved inwards more than outwards, yet the linear theory gave no account of this, and indeed assumed equal amplitudes in both directions. With difficulty, but with considerable success, they showed that a non-linear theory, treating the amplitudes as appreciable compared with the wall thickness, not only accounted for the predilection to inward buckling but also at least partially accounted for the lower critical load found experimentally.

Since the last war, and particularly during the last few years, the art of constructing large guided and ballistic missiles has advanced this problem further. These missiles have, as their principal structure, very thin tubes of large diameter ; and these tubes, from the inertia of the missile warheads and the thrust of their jets, are primarily in compression. Moreover, under the military pressure upon industry in this field, ways have been found of making such tubes with walls not of 1/100th of the tube diameter, but of 1/500th or less. In these circumstances, the old problem of the static stability of a thin tube in compression came to a head in a vital way.

Now years ago, Perry, in the textbook to which I have referred, advocated the use of internal pressure in tubular columns, attributing the original idea to Prof. Maurice Fitzgerald of Belfast. Perry once argued, I believe, that the large columns that support the present Charing Cross railway bridge over the Thames would have been better filled with air than the concrete and brickwork actually used ! Unbeknown to most missile designers, the same idea was revived by B. N. Wallis in a proposal for a single-spanarch across the Thames (instead of the present reinforced concrete Waterloo Bridge). He proposed to make the main members of his arch of tubes filled with air under pressure, this being done partly to postpone buckling and partly to control the overall deflections of the bridge under load. Some tests on tubes so pressurised were at the time carried out under Professor Redshaw at Birmingham, but the internal pressure, beyond putting the closed tube into initial tension that had first to be overcome by the applied compression, appeared to do little to prevent local buckling.

Meanwhile, missile designers, ignorant of this experience, have gone ahead and pressurised their much thinner tubes ; and by *ad hoc* tests have shown that pressurisation, in their case to the order of one-half an atmosphere, has not only provided initial tension but successfully postponed local buckling. Research into these practical results, using missile tubes in a systematic series of experiments, has in the last few years, in the U.S.A. and at Bristol, supported this experience and gone far to show the reasons.

When you pressurise a thin tubular column before loading it in compression, the first thing that happens is that initial irregularities of form (not of wall thickness) are largely smoothed out ; and this no doubt helps. But the other, and more potent, thing that happens, is that the fluid inside resists inward movement and so opposes any tendency for the walls to buckle inwards rather than outwards. As a result the mode of buckling, ordinarily a chequer-board or " square diamond " pattern, changes until with high pressure the vertical diagonal of the diamond has become so shortened relative to the circumferential diagonal that the deformation becomes, not diamond-wise, but circumferential corrugationwise, with the bulk of the deformation outwards (and so necessarily plastic rather than elastic). And the critical buckling load thus becomes substantially greater than for the unpressurised case. With such very thin tubes the engineer's " hunch," rather than his theory, was right.

In the field of tubes and shells, if we restrict attention to stability problems rather than strength ones, perhaps the most intriguing to-day is the problem of the deep-diving submarine shell. Here is a shell-like structure not under internal pressure and longitudinal compression, but primarily under heavy external hydrostatic pressure seeking to crush it and its contents. So long as submarines were thought of as surface vessels able, on occasion, to hide by diving below to a depth of 100ft or so, the problem of making the hull structure withstand the hydrostatic pressure was not very difficult. It was no more difficult than making the circular flue in a large boiler withstand the pressure of the water and steam round it—a stability problem that was studied by G. H. Bryan back in 1888. But now that submarines, nuclear powered, are thought of as living under water, and that at much greater depths, matters are more difficult. Should the structure be just like that of a conventional submarine, built as a tube with reinforcing rings at intervals? Or, in the extreme, should it be constructed as just one thick unreinforced shell in the manner of the cabin of Piccard's bathyscaphe? We are here concerned not only with elastic stability, whether linear or non-linear, but also with such heavy internal pressure that danger may arise from the metal itself yielding and becoming non-linear in its response to compressive stress. In parts of such structures, however, plasticity might conceivably be an asset in some circumstances ; Piccard, for example, after many trials and experiments, found that he could only make the windows of his spherical shell—built for submersion not to 100ft or 1000ft but to 20,000ft or more—safe by abandoning the idea that their material should be permanent and elastic in favour of making it plastic, leading to the occurrence of creep under load and hence to the need for occasional replacement. The statics of this deep submarine problem has been attempted in many ways, but is still not solved to the satisfaction either of mathematicians or engineers. We await more experiment and perhaps the new outlook of a future generation. Meanwhile, I hope and believe that engineers will still go on and make successful submarines and bathyscaphes, while science, in this case statics, chases in the rear ; a very proper position, on occasion, as between engineering and its background science.

Epilogue

It is common for engineering professors to-day to complain of the teaching of applied mathematics. Sixth-form schoolboys, when they arrive at a University, are often good at pure mathematics but poor or indifferent at its application. If this is true—and I think it is usually so—it may be due to the masters rather than the boys. How can a young teacher of mathematics, himself perhaps inspired mainly by its beauty of form, have had enough experience in its application to have felt its power and constructiveness in practical life?

But it is not at school alone that applied mathematics is taught indifferently. In most Universities the engineering under-graduates are exposed to the teaching of mathematicians mainly concerned with mathematical and science students, and in very few are the engineering students required to take applied mathematics in their final degree examinations.

One learns best, one does best, when caught emotionally by the matter in hand, and this, I think, goes for pupil, teacher, and engineer alike. And in my field it is the great structure, the sweep of an aeroplane wing, the placid beauty of an ancient bridge, the sleek pride of an ocean-going liner, the ethereal grace of a cathedral, that first catches the heart-strings of a youth and all unbeknown binds him apprentice for a lifetime.

To one caught in this way, statics can have not only the cold, if dead, beauty seen by a mathematician ; it can come alive in the hands of an engineer and help to give birth in the future, as it has in the past, to new forms, new structures of service to mankind. In the words of a famous suspension bridge designer of to-day—in one of his more poetic moments—from such efforts can come forms

> " like a star-strung frame of song,
> a gleaming harp against the sky."

that will call from one generation of engineers to the next the world over, and so perpetuate my subject.

Soil-Vehicle Systems

The first international conference on the mechanics of soil-vehicle systems is to be held in Turin on June 4-8, 1961. The subject of the conference is the relationship between vehicles and their environment, with particular reference to off-the-road locomotion and the interaction between the vehicle and the ground. The conference is sponsored by Turin Polytechnic and the British national secretary is Mr. A. R. Reece, Department of Agricultural Engineering, University of Durham, King's College, Newcastle-upon-Tyne, 2.

LETTERS AND LITERATURE

Letter to the Editor

LAST SOUTHAMPTON PADDLE STEAMER

SIR,—Pre-occupation with other matters has prevented me writing earlier to comment on Mr. Tripp's reply published in your issue of July 15th and Mr. Budd's remarks in your issue of July 29th. Both these writers appear to be taking me up on a somewhat literal interpretation of the words " paddle steamer," I certainly was under the impression that in his original article Mr. Tripp was thinking primarily of paddles as a method of propulsion, rather than steam as a prime mover, and on the appearance of the craft so propelled, which appearance would seem, according to Mr. Budd, to be so faithfully reproduced in the motor driven variety that it needs a visit to the engine room to dispel the illusion.

Before Mr. Tripp hastens to reprove me for this approach, I would put it to him that the expression in his original article " ten motor ships and three paddle steamers " suggests, in the literal interpretation of the words, that :—

(*a*) a paddle steamer is not a ship ; and

(*b*) a motor ship cannot be propelled by means of paddles,

neither of which statements are, of course, correct.

Admittedly I used the word " steamer " in the colloquial sense, just as one might say " M.V. 'Shanklin' steamed for six hours on a bearing of 300 deg," or would Mr. Budd prefer to say that she " motored."

The somewhat bizarre appearance of D.E.P.V. "Farringford" owes nothing to either the method of propulsion or the source of energy but is derived entirely from the requirement to provide facilities for vehicles to drive on at one end and off at the other, and for the ship itself to be capable of " steaming " with equal facility in either direction.

J. H. JELLETT

Chief Docks Engineer,
Southampton Docks,
Southampton.
September 1, 1960.

Book Reviews

Survival at Sea. By Lieut.-Commander G. W. R. NICHOLL, R.N. Adlard Coles, Ltd., 7, Brunswick Place, Southampton. Price 25s.

THIS book is concerned with the development, operation and design of inflatable marine life-saving equipment and is broadly divided into three sections, namely historical, operational and technical. In the first part are described the evolution of life-saving apparatus, developments during the last hundred years, the principles of the inflatable life-raft and life-jacket. The physiology of survival is touched upon and examples of life-raft rescues are quoted. The chapters in Part Two deal with stowage, launching and boarding of rafts and the various aspects and problems of living on a raft, together with notes upon raftsmanship, including manoeuvring, and towing. In that part of the book entitled technical, regulations are set out and questions of production and maintenance are discussed, followed by considerations touching upon all aspects of life-raft design. Miscellaneous items of design are next examined, such as ventilation, insulation, boardability, rough weather security, &c., and then accessories and emergency equipment are described, including the sea anchor, damage repair, rations, first-aid kit. The final chapter is concerned with future trends related to launching and manning, design and materials, and inflation equipment. The book is well illustrated with photographs and diagrams.

Telegraphs in Victorian London. By JOHN DURHAM. The Golden Head Press, 26 Abbey Road, Cambridge. Price 15s.

THE telegraph systems with which this book is concerned were operated by two companies to provide local communication in London between 1859 and 1870. One of them, the London District Telegraph Company, established a network of offices at which public traffic was accepted, and from which messengers conveyed telegrams to the addressees. All traffic passed through the company's central office in Cannon Street, where messages were transcribed and retransmitted when a line was available to the nearest office to the recipient. The delays and liability to error inherent in this method of working inspired the *Punch* cartoon which the author has chosen for his frontispiece. They were also reflected in the unexciting financial results of the company, but since the author has gathered much of his material from the contemporary press, and the press is often more interested in misfortune than success, there is plenty of entertainment in his pages.

The District company used overhead wires wherever possible, although obliged in some areas to lay its circuits as cables in the streets. The Universal Private Telegraph Company —the second undertaking with which this book is concerned—employed multicore overhead cables and rented circuits and instruments to subscribers. The direct communication thus provided proved in general a commercial success, and when both companies were merged into the new Postal Telegraphs Department under the Telegraph Act, the Universal received £184,421 10s. as compared with £64,000 paid to the District. Mr. Durham has performed a useful work in building up a picture of the two companies and their operations from the sometimes sparse and always scattered information available in the newspapers and periodicals of the day.

High Productivity in Heavy Engineering : Production, Inspection and Cost Control in Welded Fabrication. By A. G. THOMPSON, B.Sc., A.M.Inst.C.E., A.M.I.W. Iliffe and Sons, Ltd., Dorset House, Stamford Street, London, S.E.1. Price 65s.

NEW techniques in welding have revolutionised production methods for the manufacturing of plant for the nuclear, oil, chemical and other industries and in shipbuilding. Whilst avoiding what has already been written about the practice of welding, this book is concerned mainly with the technology which has been built up round welded fabrication. Its principal chapters deal with the layout and organisation of modern fabricating shops, dimensioning for accurate fabrication, metalworking processes, assembly and handling ; welding processes, quality control and inspection, cost in relation to output, the time to do a job, use of cost data, and productivity improvement. The subject matter is well supplemented by illustrations, drawings and tables, and each section includes a useful bibliography.

Electromagnetic Fields, Energy and Forces. By ROBERT M. FANO, LAN JEN CHU, and RICHARD B. ADLER. John Wiley and Sons, Inc., New York. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 96s.

THIS book is one of a series by the staff of M.I.T., designed to create a " core curriculum," and thus to " form a broad foundation on which each student could later build specialised knowledge in the subfield of his choice." This particular text is written for " junior " students who will previously have studied mathematics and physics for two years. It would, therefore, seem reasonable to assume it to be suitable for students in the second year of a three-year degree course in a British university, thus equating the final year of such a course with the " senior " year in an American university.

Many textbooks on electromagnetism appear to have been designed so to separate the mathematical theory from the engineering practice as to confound all but the most exceptionally able students. Those who have been unfortunate enough to be taught with the aid of one of these texts often fail to recover from it for many years and become so convinced of the complete uselessness of the mathematical theory of electromagnetism that certain fields of engineering activity are permanently closed to them. Sometimes the disease takes an alternative course so that the patient becomes incapable of tackling fairly elementary practical problems but seeks refuge in the production of many pages of abstruse and irrelevant mathematical analysis.

A cursory examination of the book under review might lead the reader to think that here was one more volume to be added to this already overlong list. But such a judgment would be quite unwarranted. To begin with, the authors assume that the students will have taken a physics course which has led up to and terminated in the formulation of Maxwell's equations. One of the main purposes of such a course would presumably be to describe the physical properties of electromagnetic systems and to show how these may be given mathematical formulation.

Secondly, the authors take great care to relate the theory developed to a number of practical problems. Working from Maxwell's equations the student is led to consider as special cases, static fields, slowly-varying fields and lumped-element network theory. The approach to the latter subject is treated more coherently and sensibly than in any other textbook known to us and a study along these lines should certainly be part of the work done in the first half of a

degree course. The study of energy and power in electromagnetic systems, the behaviour of moving systems and an introduction to the special theory of relativity are all covered in a skilful manner. Indeed, the only major doubt about the content of the book arises in relation to the use made of the concept of magnetic charge. The justification for the introduction of this concept is that it is mathematically convenient, but in view of the fact—repeatedly stressed by the authors—that there is no experimental evidence upon which the concept might rest, we would prefer a treatment which was based on circulating currents and magnetic dipoles.

However, although the mathematical theory and physical behaviour of systems are treated in a satisfactory and well-integrated manner, it is very doubtful whether many university teachers would be prepared to recommend the book as a whole to students in the second year of a degree course. Although several sections of the book could be studied at this stage, yet it is the experience of the reviewer that two years' study in the university is required if the student is to possess a thorough grasp of electromagnetic theory and practice and is to understand the formulation of Maxwell's equations. Only in the final year, and even then, for honours degree men only, does a complete treatment of the kind here envisaged become a practical possibility.

It is, of course, true that each teacher tends to regard as difficult those branches of a subject which were taught to him late in his career as a student. The Massachusetts Institute of Technology has been a pioneering body in the attempt to reassess the content of electrical engineering courses in order to create a curriculum more suited to the present and future state of the engineering sciences than the one traditional in most universities. But experiments made in one or two departments in British universities suggest that a course may appear to succeed, although the students have gained little other than a facility in handling fairly orthodox mathematical routines and have failed to grasp the fundamental principles the course was designed to drive home. Although no reader of this textbook ought to be dogmatic about it a case could be made for regarding the book as an admirable one, but more appropriate to a later stage in the education of the engineer than that envisaged by its authors.

Explorations de la Couche Limite, en Turbulence Naturelle et en Turbulence Provoquée, dans le cas d'un Ecoulement Supersonique le long d'une Plaque Plane. By JEAN-FRANCOIS DORAND. Publications Scientifiques et Techniques du Ministère de l'Air, No. 355. Paris: Magasin C.T.O.: 2, Avenue de la Porte-d'Issy, Paris (15e). Price Fr.2830.

AN experimental study of the establishment of turbulence on a plane surface in an air stream at Mach=1·85, carried out by the author, has brought to light some interesting new information. The boundary layer was investigated dynamically and thermally and the " natural transition " was compared with that artificially promoted by fine wire stuck to the surface at right angles to the direction of flow.

In the case of the natural smooth surface an increase in the boundary layer thickness was found even where no longitudinal pressure gradient existed. This increase—of the order of 0·1mm—is followed by a decrease after the transition point when turbulence is fully developed. Similar but more rapid changes were observed with the surface equipped with a wire. The work was carried out in the supersonic wind tunnel of the C.N.R.S. at Bellevue.

Automatisierung durch Pneumatik und Hydraulik. By E. KÖNIG and W. PFENNINGER. No. 26 of the TR special series. Berne: Verlag Technische Rundschau, Hallwag, Bern, Nordring 4. Price S.Fr. 5.80.

A FURTHER increase in automation can be realised only if designers as well as production engineers are made thoroughly familiar with the basic elements from which complex pneumatic and hydraulic installations are built up. The present number of the TR special series is devoted to a detailed discussion of operating and control elements and their various specific advantages and shortcomings. Among these design elements are lip seals (" U " and hat rings), " O " rings, pipes and hose connections, fittings, valve blocks, water separators, reducing valves and oil mist lubricators, one-way and multi-directional control valves, pistons and cylinders, valves, delay elements, exhaust silencers, piston buffers and hydraulic fluids. Fundamental control circuits are illustrated by complete sectional drawings and examples.

Practical Welding Repairs. By C. G. BAINBRIDGE, M.I.Mech.E. Temple Press, Ltd., Bowling Green Lane, London, E.C.1. Price 15s.

THE use of welding for repair work is now universal and although, as every welder well knows, no two jobs are the same, certain rules and procedures must be followed in all cases to get the best results. It is the aim of this book to assist the practical welder by describing the most suitable techniques which can be applied in the variegated tasks which come within the wide scope of general repair welding. Following a useful practical introduction into the properties of metals four sections deal in detail with the welding of wrought metals, castings, the rebuilding and hard facing of worn parts and miscellaneous repairs. Most of the information and hints on procedure given are based upon actual practical experience. No attempt is made to describe how oxy-acetylene or arc welding should be done but a useful chapter deals with the care of equipment and operating safety.

In each section the reader is given guidance as to how the different metals behave under welding conditions, the way to prepare joints for economical and effective welding, the best process suited to a particular job and the best procedure to follow to ensure good welds under various conditions. A number of useful tables and charts are included in the book together with drawings to clarify details where necessary. This book will be read with interest by practical welders and it provides a considerable amount of valuable information for newcomers to the trade which makes it a useful addition to the literature on the subject of welding.

Books of Reference

Hydraulic Handbook. Trade and Technical Press, Ltd., Morden, Surrey. Price 100s.—This is the second edition of the handbook and contains sections dealing with all aspects of hydraulic problems. The first section discusses the principles of hydraulics, commencing with oil as a hydraulic medium and concluding with speed control of hydrostatic mechanisms. There is a survey of hydraulic equipment, ranging from accumulators to valves, and this is followed by a section concerned with the industrial applications of hydraulics and refers to agricultural, aircraft, railway, marine, mining, mechanical handling and machine tool industries, &c. The data which occupy over 500 pages are extensively illustrated with diagrams and drawings. About 150 pages are devoted to technical data which include diagrams of circuits, formulae, tables, nomograms, symbols and a dictionary. The final section of the handbook is a comprehensive buyers' guide.

Spectrochemical Abstracts, Volume VI, 1954–55. By E. H. S. van Someren, B.Sc., and F. Lachman, Dipl. Ing. Hilger and Watts, Ltd., 98, St. Pancras Way, London, N.W.1. Price 25s.—The abstracts, each of which is numbered, are grouped in three divisions, the first being concerned with substances analysed. These relate to: biological minerals; ceramics and slags; gases, oils and liquids; minerals; non-metallic solids; and metals and alloys. In the next division, entitled apparatus and techniques, are included apparatus, methods and source theory abstracts. There follows a bibliographical section, an index of elements and an author index with associated abstract numbers.

Geometric Properties of Rolled Sections and Built Girders. Volume I. Lloyd's Register of Shipping, 71, Fenchurch Street, London, E.C.3. Price 63s.—This volume deals with British and U.S.A. sections and has been prepared to assist ship designers to select the appropriate sections to satisfy the requirements of the Society's revised rules for oil tankers. The section modulus given by the formulae in the rules refers to a stiffener in association with 24in of plating and the volume contains curves of constant web thickness plotted so as to give the section modulus with plating of varying thickness for a particular section. The area of the section is also given so as to facilitate the selection of the most economic section. In similar manner curves give the moment of inertia in association with varying thicknesses of plating and there is also a set of curves from which the section modulus of built-up girders can be determined.

Books Received

Nuclear Engineering Monographs, No. VIII: Nuclear Radiation Measurement. By J. Sharpe. Temple Press, Ltd., Bowling Green Lane, London, E.C.1. Price 12s. 6d.

Nuclear Engineering Monographs. No. IX: Nuclear Reactor Optimization. By P. H. Margen. Temple Press, Ltd., Bowling Green Lane, London, E.C.1. Price 12s. 6d.

Vacuum Processes in Metalworking. By J. W. Cable. Reinhold Publishing Corporation, New York. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 44s.

Process Engineering Calculations: Material and Energy Balances. By Mack Tyner. The Ronald Press Company, 15, East 26th Street, New York 10, N.Y. Price 8.50 dollars.

The Directory of Opportunities for School Leavers, 1960. Edited by Clive Labovitch. Cornmarket Press, Ltd., Darley House, 1, Lower James Street, London, W.1. Price 8s. 6d.

Encyclopedic Dictionary of Electronics and Nuclear Engineering. By Robert I. Sarbacher. Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, London, W.C.2. Price 160s.

Theory and Application of Mechanical Engineering Measurements. By Mark B. Moore. D. Van Nostrand Company, Ltd., 358, Kensington High Street, London, W.14. Price 51s.

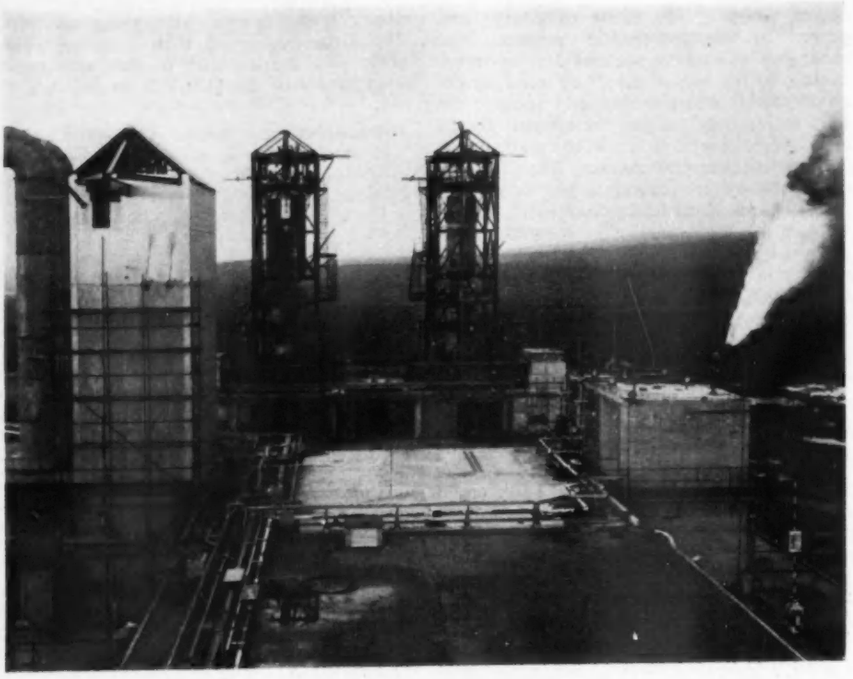
Heat Bibliography, 1958. Department of Scientific and Industrial Research, National Engineering Laboratory. H.M. Stationery Office, York House, Kingsway, London, W.C.2. Price 15s.

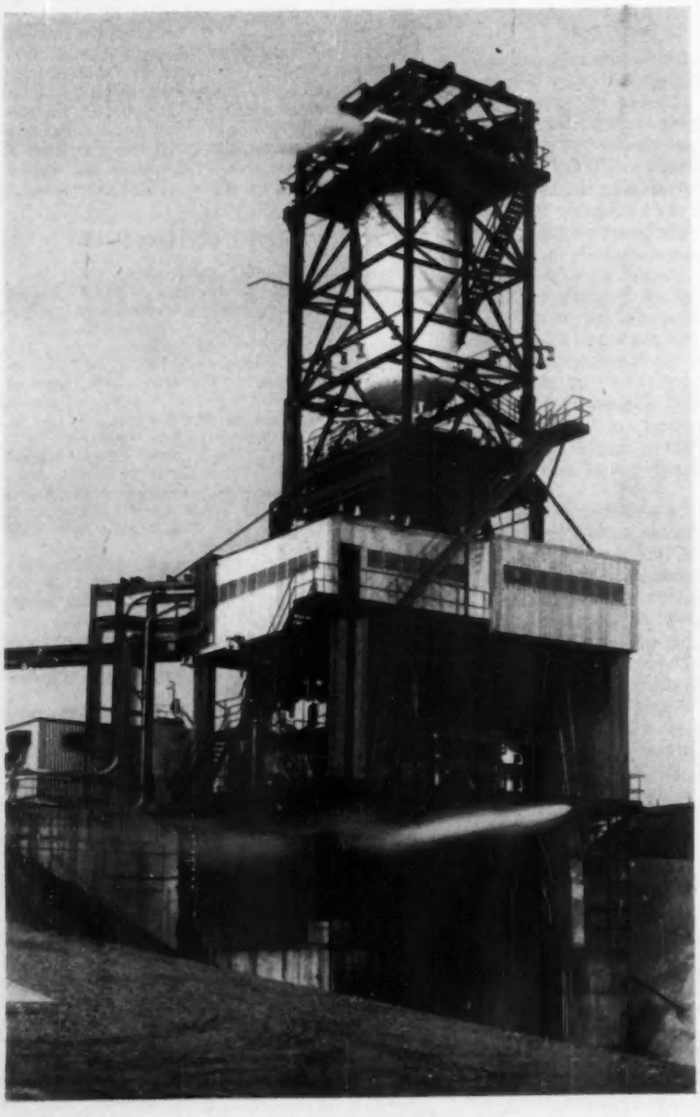
Symposium on Surface Effects on Spacecraft Materials. Edited by F. J. Clauss. John Wiley and Sons, Inc., New York. Chapman and Hall Ltd., 37, Essex Street, London, W.C.2. Price 92s.

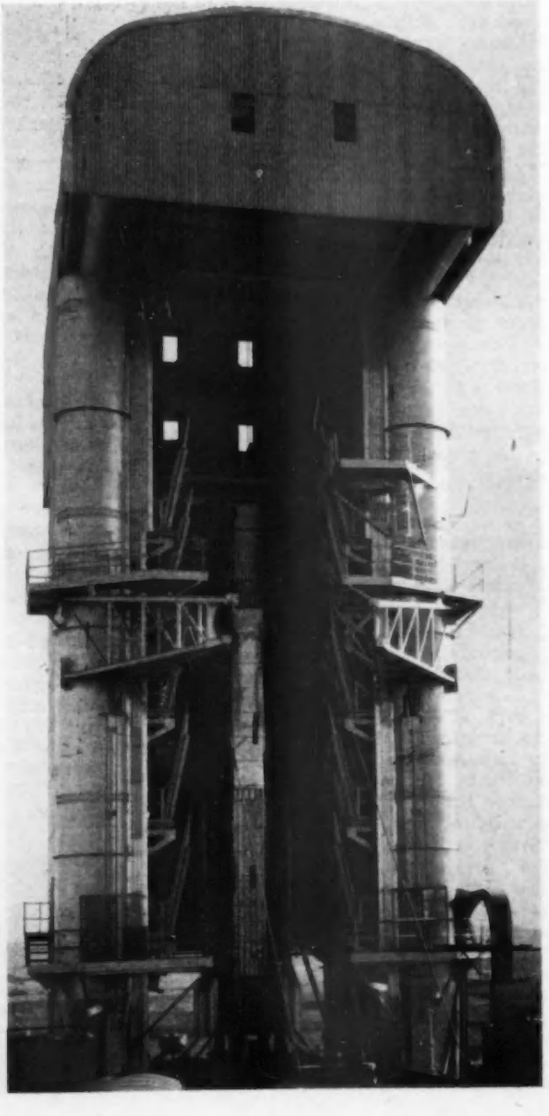
The Internal-Combustion Engine in Theory and Practice. Vol. 1. *Thermodynamics, Fluid Flow, Performance.* By C. Taylor. John Wiley and Sons, Inc., New York. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 128s.

Modern Air Conditioning, Heating and Ventilating. Third edition. By Willis H. Carrier, Realto E. Cherne, Walter A. Grant, and William H. Roberts. Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, London, W.C.2. Price 80s.

Rocket Engine Testing







For developing and ground testing the liquid oxygen propulsion system for the ballistic missile " Blue Streak," the Spadeadam Rocket Establishment was undertaken by the Ministry of Works on behalf of the Ministry of Aviation ; the facility was built by British Oxygen, Ltd., and Wimpey, Ltd., in conjunction, and is operated by Rolls-Royce, Ltd. Construction commenced in January, 1957, and is still not complete ; two facilities, however, are working, a component test area and an engine test area. There is also a missile test area in which there are under construction two test stands with mobile servicing towers, irresistibly evocative of those seen on launchers for ordinary missiles.

As was mentioned above, the establishment exists to test liquid oxygen engines, and an air condensing and distilling plant has been installed by British Oxygen Engineering, Ltd. ; the oxygen consumption is too low to justify a tonnage oxygen plant, and a pair of reciprocating plants of 50 tons per day output each was built.

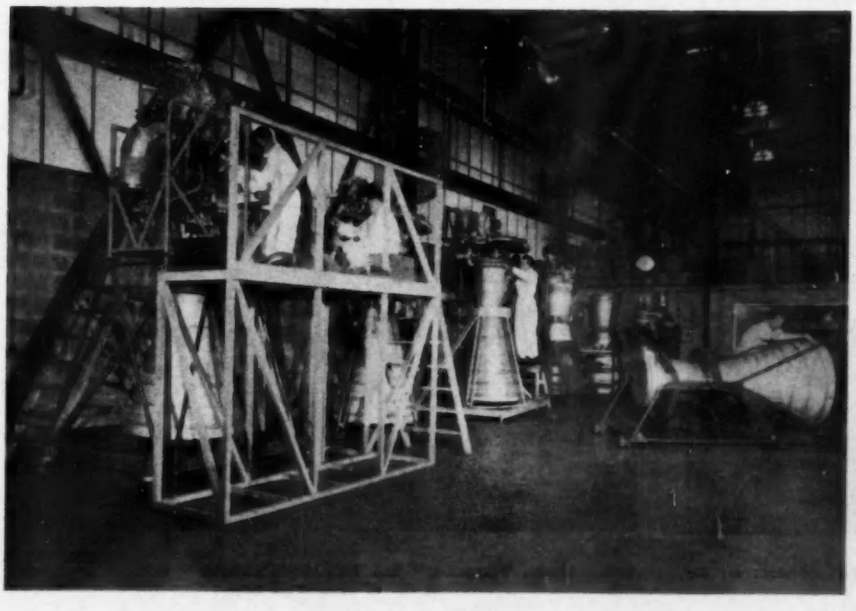
The component test area is seen OPPOSITE, TOP. At the far end are a pair of stands for testing pump-turbine assemblies ; one is equipped for pumps handling only fuel and water, but in the other fuel and liquid oxygen (lox) can be pumped and returned to the tanks in the upper storeys. The incomplete building whose roof occupies the foreground is also devoted to pump and gas generator development, and the fuel-rich exhaust of a generator can be seen burning in the air. The two tall stacks at the left carry the exhaust gases from a pair of R-R " Avon " RA-7 engines which have been installed with power take-off from the turbine, making available several thousand shaft horsepower for the testing of pumps ; the power is fed into transmission dynamometers and must of course pass through speed-increasing gears before use in realistic pumps. In this area also is a facility considered to be unique and useful, a High Flow Water Test building in which pumps, valves, flowmeters, nozzles, &c., can be tested ; three pumps make available flows up to 2000 gallons per minute at 950 lb per square inch or 6000 gallons per minute at 300 lb per square inch.

The engine test area has four stands, one of which, however, was built merely to allow engines installed in a vehicle to be tested pending completion of the missile test area. The fourth stand, still incomplete, is expected to prove by far the cheapest, being built of prestressed concrete. The remaining two are, like the engines, closely based on North American practice, and the valves, solenoids, microswitches and other equipment on them are principally of United States origin. The stands are 250ft apart ; to avoid the risk of the whole area being burnt out by failure of a missile under test, only one tank of a missile is filled at a time, the other propellant being pumped from the site storage tanks. The engine test stands proper have their own tanks installed. Each test stand has a flame deflector, seen LOWER LEFT, OPPOSITE, cooled by water injected in large quantities through holes in the impingement face ; the water is in a closed circuit with a 1,000,000-gallon reservoir and, although the site is not merely isolated but enclosed, elaborate provisions are made to remove from the water dirt as well as unburnt fuel. Fire precautions are necessary to protect the surrounding peat as well as the plant, and the equipment includes 4 × 4 Thornycroft and 4 × 2 Thames appliances.

A " Blue Streak " can be seen in the engine test stand built to house it in the illustration OPPOSITE, BOTTOM RIGHT. Details which may not be familiar are that the rings comprising the oxygen tank are joined, with a spotwelded internal cover strap, at an angle such that the tension perpendicular to the joint line is a minimum. The structural joint, part way up the tapered section, is effected by nuts and bolts, one in each top-hat stiffener. There are at the top end four and at the bottom end two points at which a tension of 16,000 lb is applied to support the shell in transport. The removable fairings on each side of the propulsion bay each cover, among smaller items, two rows of five spheres of nitrogen under pressure, and pipes carrying the gas to pressurise the tanks run up the outside of the vehicle.

The engines so far built in this country are the RZ-1 and the RZ-2 Mks 1 and 2,

all generally similar to the Rocketdyne engine boosting " Atlas " and sustaining " Thor " and " Jupiter " ; few of the RZ-1 were completed, while the RZ-2 Mk 1 differed from the present engines principally in being less close to a complete power plant. For these engines, a thrust of 135,000 lb is quoted but not guaranteed, together with a weight of 1500 lb and a length of 7ft. One obvious difference from the original engine is that the divergent portion of the nozzle is simplified from the original low-loss profile to a cone. This would be expected to effect an improvement in specific impulse when far below design altitude, due to the increased susceptibility to separation, but in fact the performance in this condition is exactly the same (no Rolls-Royce engine has yet been tested at other than sea level static conditions) ; this is the more surprising in that the design altitude is low (8 lb per square inch pressure) and suggests that on the heavily loaded " Blue Streak " efficiency was sacrificed for take-off thrust. The engine is seen ABOVE ; the near-spherical component below the turbo-pump is the gas generator. Above the turbine is the fuel pump and on the other end of the same shaft the oxidant pump. The chamber proper can be seen more clearly LEFT : the fuel is fed into the manifold surrounding the front of the chamber periphery, whence it flows down half the tubes to the end of the nozzle and back along the other half ; it then enters the sprayer head and passes through numerous concentric circular slits into the combustion chamber. The oxygen is fed directly into a sprayer in the centre of the chamber head ; on the engines which had been fired the walls were conspicuously a sooty black, suggesting that the outer regions remain fuel-rich right to the end of the divergence. The oxygen sprayer is a strong casting and on its outer face is mounted the gimbal accepting the engine thrust, a simple cross type universal joint with grease-gun lubrication. The frames by which pivoting forces are applied to the nozzle are conspicuous ; in the course of its several test runs, each individual engine has its thrust vector accurately aligned with the mountings. Because the " Blue Streak " has two engines burning throughout its powered flight, exceedingly accurate thrust cut-off is necessary to prevent severe tumbling of the falling vehicle, and this has been achieved to the extent that no vernier engines are necessary with RZ-2 engines in a medium range missile.



Pneumatic Tyred Compaction Rollers

Three models of pneumatic-tyred compaction rollers now being manufactured by Armstrong Whitworth (Metal Industries), Ltd., include a 15-ton and a 22-ton self-propelled machine and a heavy-duty towed machine in three sizes of 30, 50 and 100 tons capacity. Each of these machines incorporates a design of suspension which maintains the weight equal on all wheels irrespective of ground contour.

LAST week there was demonstrated at the works of Armstrong Whitworth (Metal Industries), Ltd., Gateshead-on-Tyne, the first machine of a range of pneumatic-tyred compaction rollers the firm is manufacturing, and marketing in this and a number of overseas countries, under an agreement with the Albaret company of France. This design of compactor is claimed to have a number of advantages over conventional steel-wheeled rollers owing to the fact that pneumatic tyres cover all ground irregularities, and have no tendency to miss soft areas between high hard spots which can be "bridged" and missed by steel rollers. Further, the pneumatic tyres impart a kneading action which results in homogeneity of the compacted soil. The Albaret machines incorporate what is termed an "Isostatic" form of suspension by which constant individual loading is maintained on all wheels irrespective of the ground contour. Three designs of these machines are being made by Armstrong Whitworth (Metal Industries), Ltd.: the self-propelled 15-ton "Autopactor"; the 22-ton self-propelled "Isopactor"; and heavy-duty towed "Pullpactor" compactors of 30, 50 and 100 tons weight. By varying the tyre pressures in these machines they can be used equally well for both base-formation compaction and surface rolling.

The "Autopactor" machine, seen in our first illustration, has a set of three front (steering) wheels and four rear (traction) wheels, fitted with 12·0 by 18 tyres, giving a maximum rolled width of 77in. Its heavy section welded steel frame, which bridges the ballast box, is designed to keep the centre of gravity low and distribute the weight between the two rows of wheels so that the weight on each wheel is just over 2 tons. A six-cylinder 86 b.h.p. Ford diesel engine set high on the frame drives a four-speed gearbox through a fluid coupling. The four speeds available in forward and reverse range from 2·5 to 12·5 m.p.h., and direction of travel is selected through a twin-clutch mechanism, the operation of which is synchronised with the throttle control.

The four rear wheels are arranged in two pairs and the drive to each pair is taken from shafts extending from each side of a differential box through chains to the axle of each pair of wheels. The axle of each pair of wheels is arranged to oscillate about its centre support to enable the wheels to conform to surface contour and maintain equal load distribution without affecting driving torque. For special working conditions oscillation of the rear axles can be limited or suppressed by the fitting of adjustable stops.

The three-front-wheel assembly is supported from a rocking bolster pivoted at its centre to a king post through which power-assisted steering is effected. The off-side pair of wheels is carried on a short axle pivotally mounted on one bolster arm and the nearside wheel rotates on a fixed trunnion on the other arm. With this arrangement the bolster can pivot on the centre post and the axle of the off-side pair of wheels on the bolster to give a combined oscillating movement in accordance with ground contour conditions. Full stability of the vehicle is maintained by the "three-point" suspension provided by the two pairs of rear wheels and the centre support of the steering bolster irrespective of ground contour whilst equal loading is maintained on all wheels.

The main ballast box and two removable side boxes provide accommodation for 160 cubic feet of loose ballast which can be discharged through doors in the base to lighten the machine for road travelling between sites. When filled with sand ballast the machine has an all-up weight of 33,000 lb (giving a 4700 lb loading on each tyre) and without ballast it weighs 15,500 lb. A sprinkler equipment, fed by 100-gallon tanks, supplies individual sprinklers and mats at each wheel. Standard lighting equipment to highway running requirements is fitted and a small air compressor, driven from the engine, can be used for tyre inflation when necessary.

The "Isopactor," which weighs 22 tons fully ballasted and 12 tons unladen, can be seen in our second illustration. It consists of a main "T"-shaped chassis carried on five (steering) wheels at the front and two (driving) wheels at the rear. Into each of the recesses on each side of this chassis there is fitted an auxiliary chassis, which pivots towards its forward end on a shaft across the main chassis and has a wheel at the rear driven by chains from a universal shaft extending from the side of the main drive box. The machine is thus designed to operate with five forward and four rear compaction wheels. The main central chassis carries the engine, transmission, steering and other main units, whilst the auxiliary chassis incorporate ballast sand boxes. Cast iron ballast weights can also be slung to the underside of the ballast boxes and the working weight of the machine can be adjusted as required from 26,500 lb to 48,500 lb. With the method of suspension described below this working weight is distributed evenly over all nine wheels.

This machine is also driven by a Ford 86 b.h.p. diesel engine, power being transmitted through a fluid coupling and a four-speed gearbox giving forward and reverse speeds from 1·9 to 8·8 m.p.h. Mechanical hydraulically-assisted steering is provided and can be operated from wheels situated inside the driving cab and on a platform at the side, as shown in the illustration. Through a special lever mechanism built in the steering assembly, differential cornering angles are imparted to all five front wheels to eliminate "wheel skid" and disturbance of the soil surface. Each of the front wheels is carried through its forks on the ram of a hydraulic cylinder so that the wheels follow ground contour whilst their even loading is maintained constant by the hydraulic pressure fluid system. The two wheels on the off-side are fed from one common hydraulic supply and the three on the near-side from a second supply so that, when required, the two sets can be arranged to work at two different elevations as necessary in road shoulder formation. In this particular application the stability of the machine remains unaffected, and the equal loading on all wheels is maintained by the hydraulic system. The vertical movement

Self-propelled 15-ton compactor in use compacting bunter sandstone on the Doncaster by-pass

22-ton Albaret "Isopactor" and 100-ton "Pullpactor" working on a new runway of Le Bourget airport

available through the hydraulic suspension system makes possible a total difference of 16in in elevation of any two wheels.

Each of the two outside rear driving wheels of the pivoted side-chassis members can move up and down to conform to ground contour irrespective of the height of the two central wheels on the main chassis. The complete overlap of the five front and four rear evenly loaded tyres gives a minimum coverage width of 90in. An engine-driven compressor is provided for tyre inflation and tyre working pressures from 26 lb to 143 lb per square inch can be used.

At the side of the " Impactor " shown in our illustration there can be seen a 100-ton " Pullpactor " in operation. This design of towed machine consists essentially of a welded plate chassis structure incorporating large ballast boxes at each end, and having a central " well " across its width in which the line of compactor wheels is situated. Each of the four compactor wheels is axle-mounted in a separate " rocker " housing which is hinged from brackets on one of the chassis cross members. These housings, which enable the wheels to raise and lower to ground contour, are connected in adjacent pairs by wire ropes which pass around freely rotating pulleys anchored at the opposite side of the chassis well to the pivots. With this method of controlling the up-and-down movement of the pivoted housings when one wheel is raised by ground contour the complementary wheel is lowered an equal amount, whilst equal loading is maintained on both wheels. The ends of the wire ropes are hitched on to pegs in the housings and any of a number of pegs set in a row on the housings can be selected to adjust the machine for the required ground clearance. Further, if it is required to set any particular wheel to work at a lower level than the others, such as when compacting a trench base, its wire rope is hitched on a selected peg to give it a lower setting. In such cases the stability of the vehicle is unaffected and individual wheel loading is maintained equally.

The machine can be pushed or pulled and during transport or for surface finishing purposes the suspension housings can be bolted together in line. Sand or cast iron slabs can be used for ballasting. The 30- and 50-ton machines are of single unit construction, but the 100-ton machine which has an overall width of just under 11ft is made in two separate parts coupled together down the longitudinal centre line. These two independent body sections can be hauled separately between sites.

We are informed that in addition to these pneumatic-tyred compactors Armstrong Whitworth (Metal Industries), Ltd., has also entered into an agreement covering sales and service for other products of the French company.

Heating of Power Station Buildings

A sub-committee was appointed by the Central Electricity Generating Board to examine the operating conditions and costs of heat pumps installed to heat generating station offices and to compare the results with those obtained from other forms of heating. The study, extended over three years, has established that overall seasonal performance energy ratios of between 5 and 6 may be obtained for heat pumps at generating stations using cooling towers where a representative mean seasonal low grade heat source temperature of 73 deg. Fah. and output temperatures of 130 deg. Fah. may be obtained. The corresponding value of the ratio for river-cooled stations approaches 3·0 where the representative source temperature is about 14 deg. Fah. lower, i.e. 59 deg. Fah. Where the source is as warm as or warmer than at the cooling tower stations, i.e. 73 deg. Fah, the heat pump has a clear advantage on the score of fuel economy, e.g. with a performance energy ratio of 5 the same useful heat can be provided by the heat pump for only half the amount of basic fuel used by a direct steam heating system. The report is reproduced here.*

A RANGE of similar buildings each heated by a different method and situated within a similar climatic region was selected for study ; details are given in Table II. It was necessary to ensure as far as practicable that the comfort conditions appropriate to the particular heating system were at all times maintained, although the internal temperatures varied with the type of heating, i.e. with floor warming a slightly lower air temperature than that required by more conventional means of heating may be used in offices. The heat pumps studied in detail were those at Stourport and Meaford (Midlands Division, C.E.G.B.), while those which have more recently been installed in the generating stations at Cowes (Southern Division), and South Denes (Eastern Division) were examined on a broader basis.

Having regard to the varying sizes and locations of the buildings studied, adjustments were made to the final data obtained so that all referred to a building similar in size to the administrative building at Meaford Generating Station which is heated by the heat pump. The original capital costs of the installations studied were also adjusted to price levels obtaining in 1956. The full costs adopted, including in the case of electricity, kilowatt demand charges, were those prevailing during 1956-57. Because of the trend of electricity supply costs, the economic case for off-peak electrical heating systems should improve.

To relate the annual operating costs actually obtained for the generating station buildings to those which might be anticipated in comparable buildings operated by a landlord on a normal commercial basis, a table has been prepared using appropriate fuel prices, (Table V).

The investigation into other systems for heating the administrative offices of generating stations covered the following :—

Direct Electric Systems :
- Electric tubular heaters ;
- Electric convectors.

Central Heating Systems :
- Bled steam hot water convectors ;
- Auto-solid fuel boiler water radiators ;
- Oil-fired boiler ceiling panels ;
- Electrode boiler with storage (ceiling panels) ;
- Electrode boiler without storage (ceiling panels).

Floor Warming Systems :
- Withdrawable electric floor warming (two installations).

To increase the usefulness of the final tables the capital cost appropriate to directly embedded cables has been used for one of these, the running costs being unaltered. Although, initially, an electrical tubular heating system, an electrical convector installation, and an electrode boiler without thermal storage plant were included in the study, it is not considered that direct electrical systems, giving rise to peak demands, are to be recommended for use in power station buildings, especially since it is necessary to allocate a substantial annual fixed charge against each kilowatt installed.

In all cases, electrical energy for heating purposes was separately measured. Coal and oil were separately stacked and weighed and the calorific value calculated. Recording thermographs were located to give representative temperature conditions in the office buildings. For outside air temperatures the external maximum and minimum temperatures normally observed daily by the station staff were used. The output of the bled steam installation was obtained by means of a condensate meter.

Operating Conditions of Heat Pumps

The general characteristics of the heat pumps. Both were of the water-to-water type and consisted of a reciprocating compressor driven by an electric motor, an evaporator and condenser, both of the shell and tube type, and an expansion valve. Initially both operated on methyl chloride but a change to Arcton-6 (Freon-12) was made after the first year in the case of the larger unit. Operation of the systems was controlled by a thermostat situated in a thermal storage tank interposed between the condenser and the building heat distribution system. The warm waste water source for *A* came directly from cooling towers. The source water for *B* was pumped from an outflow culvert to a river and consequently can be expected to be lower in temperature than the source for *A*.

Performance of the Heat Pumps

Temperatures in the water and refrigerant circuits, the rates of flow of the water in the evaporator and condenser, and pressures at

Table I—*Characteristics of Heat Pumps*

	Heat Pump *A*	Heat Pump *B*	Remarks
Capacity of plant (maximum rated output)	132kW at source, temperature 80 deg. Fah.	95kW at source, temperature 38 deg. Fah.	Given by manufacturers, J. and E. Hall, Ltd.
Source of low-grade heat	Taken from flow pipe to cooling towers	Pumped from outflow culvert to river	—
Method of heat distribution in office building	Ceiling coils with floor coils in corridors	Ceiling coils with floor coils in corridors	—
Type of building	Three-storey office block	Three-storey office block	Both with bridge to turbine house.
Compressor type and rating	2 × 27·5 h.p. reciprocating	1 × 34 h.p. reciprocating	At *A* one is used as standby
Heat exchangers	Shell and tube	Shell and tube	Both insulated.
Rate of hot water flow	$14·1 \times 10^5$ lb/hr. ...	$23·1 \times 10^5$ lb/hr. ...	—
Rate of cold water flow...	105×10^5 lb/hr.... ...	$108·68 \times 10^5$ lb/hr. ...	Affected by fouling of evaporator surface.
Refrigerant	Arcton-6 (Freon-12)	Methyl chloride ...	Changed October, 1955, from methy chloride.
Mean rate of flow of refrigerant	6300 lb/hr.	1900 lb/hr.	—
Auxiliary plant...	Source pump, condenser pump, hot water distribution pump	Source pump, condenser pump, hot water distribution pump	Usually main cooling tower pump is utilised

* Mr. F. W. Skelcher (chairman), Midlands Division ; Miss M. V. Griffith, Electrical Research Association ; Mr. W. Gilchrist, Merseyside and North Wales Electricity Board ; Mr. V. G. Newman, C.E.G.B. Headquarters ; Mr. R. F. Richardson, South-Western Electricity Board ; Mr. J. Solari, Cowes Generating Station ; Mr. W. A. Clement, Midlands Division ; Mr. N. C. Mander (secretary), Midlands Division.

TABLE II—*Analysis of Systems Under Review 1956-7 Heating Season*

	Power station	Units	Derivation	Westwood	Roosecote	Ince	Stourport	Meaford "A"	Meaford "B"	Bold	Connahs Quay
1	Heating plant	—	—	Auto-fired coal boiler	Auto-fired oil boiler	Bled steam	Heat pump river source	Heat pump cooling water source	Electrode boiler with thermal storage	Directly embedded floor warming	Ducted embedded floor warming
2	Heat distribution system	—	—	Free standing radiators L.P.H.W.	Ceiling embedded panels L.P.H.W.	Inset wall convectors	Ceiling coils	Ceiling coils	Ceiling and floor embedded panels		
3	Nominal date of completion	—	—	1953	1954	1954	1948	1949	1955	1954	1954
4	Operational routine	—	—	Continuous	Continuous	Continuous	Continuous	Continuous	7 p.m.-7 a.m. + Mid-day boost	Off peak	Off peak
5	Method of temperature control	—	—	Thermostat auto	Thermostat biased	Thermostat controls valves	Hot water thermo-stat	Hot water thermo-stat	Thermostat biased	Individual room thermo-stats	Individual room thermo-stats
6	Volume heated	Cu. ft	—	97,050	516,150	278,000	74,400	176,460	80,300	112,841	442,390
7	Control room incorporated in office block	—	—	No	Yes	Yes	No	Yes	Yes	No	Yes
8	Exposure	—	—	Normal	Severe	Normal	Sheltered	Sheltered	Sheltered	Normal	Normal
9	Design temperature for occupied rooms (including test room)	Deg. Fah.	—	68	64	68	64	64	64	64	64
10	Design external temperature	Deg. Fah.	—	30	30	30	30	30	30	30	30
11	Design temperature rise	Deg. Fah.	(9)−(10)	38	34	38	34	34	34	34	34
12	Allowance for adventitious heat gains	Deg. Fah.	—	3	3	3	3	3	3	3	3
13	Design temperature rise for heating system	Deg. Fah.	(11)−(12)	35	31	35	31	31	31	31	31
14	Calculated building heat loss (See note)	B.Th.U./Hr./1 deg.	—	8,688	38,739	23,950	6,260	14,459	9,374	10,530	34,296
15	Calculated heat requirement from heating system	B.Th.U./Hr.	(13)×(14)	304,080	1,200,909	838,250	194,060	448,000	290,594	326,430	1,063,176
16	Calculated heat requirement from heating system	kW	—	89·3	353	246	57	131	85	96	312
17	Loading installed	B.Th.U./Hr.	—	341,200	1,272,000	1,050,000	324,000†	450,000	1,023,000	361,600	1,282,000
18	Loading installed	kW	—	100	373	308	95†	132	300	106	376
19	Plant amortisation period	Years	—	25	25	40	25	25	25	40	40
20	Boiler-house amortisation period	Years	—	40	40	40	40	40	40	—	—
21	Plant capital charges	Per cent	—	8·5	8·5	7·5	8·5	8·5	8·5	7·5	7·5
22	Boiler-house capital charges	Per cent	—	7·5	7·5	7·5	7·5	7·5	7·5	—	—
23	Capital costs (See note)	Pounds	—	4,000	8,803	7,535	7,760	10,080	5,112	1,197	7,52

NOTES.—(14) Using coefficients taken from I.H.V.E. guide, allowing one air change per hour.
(23) Capital costs include plant and heat distribution systems referred to 1956-7 values.

† Considerably oversized : allowance made for this.

various parts in the refrigerant circuit were continuously recorded, and the observations made over the second and third years of the tests are set out in Table III. This also includes the weather conditions and the temperatures provided in the office buildings. The maximum temperature of the source water was increased in the third year, while for reasons connected with the operation of the main process, the minimum source temperature for *A* fell towards the end of this year.

The energy used by auxiliaries such as source water and condenser cooling water pumps reduced the values of the Performance Energy Ratio (P.E.R.) for the heat pumps alone by about 10 per cent. The efficiencies shown in Table III for the compressor and motor systems and for the condenser and evaporator are characteristic values. The efficiency of the evaporator was always greater than 100 per cent, probably due to absorption of heat from the condenser lying below it. The effective performance of the heat pumps should be judged by the overall seasonal values of P.E.R. given in Table III. These are based on the calculated annual heat requirements of the buildings and the total annual electrical consumption of *A* and *B* respectively.

COMPARISON OF COST

The investigations described have indicated that the comparative overall operating costs of heating systems, when installed in a generating station administrative building such as Meaford " A " of 176,460 cubic feet, (448,000 B.Th.U. per hour heat deg. Fah. loss), will be as follows :

TABLE IV—*Comparative Heating Costs (Internal Fuel Prices—C.E.G.B.)*

Overall operating costs (includes fuel, attendance, maintenance and capital charges)

Heating system	Relative annual cost
Bled steam	1·0
Directly-embedded floor warming	1·06
Ducted floor warming	1·27
Heat pump cooling water source	1·57
Oil-fired boiler	1·73
Coal-fired boiler	1·80
Heat pump river source	1·96
Electrode boiler	2·16

The above table has been based upon the fuel and electricity unit costs applicable internally to the Central Electricity Generating Board.

It is clear from the above that floor warming by means of directly-embedded electric conductors is not only the simplest but, next to bled steam, the most economical method of space heating for power-station administrative blocks. It has the added advantage that individual offices or sections of the building can be separately controlled, thus effecting economy, particularly where the control room is an integral part of the office block.

The following table indicates the general comparable costs of heating a building of 448,000 B.Th.U. per hour heat loss by various means—when the fuel or electricity charges are assumed to be (on average) those applicable to commercial consumers of the Electricity Boards :

TABLE V—*Comparative Heating Costs (Commercial Fuel Prices)*

Operation	Heating system	Overall Operating costs £	Relative annual cost
Continuous	Bled steam	1524	1·0
Off-peak	Directly-embedded floor warming	1540	1·01
Continuous	Oil-fired boiler	1585	1·04
Continuous	Heat pump cooling water source	1610	1·06
Off-peak	Ducted floor warming	1793	1·18
Continuous	Auto-fired coal boiler	1956	1·28
Continuous	Heat pump river source	2179	1·43
Off-peak	Electrode boiler with thermal storage	2862	1·88

Fuel Unit Costs :
Electricity—£7 per kW of M.D. plus 1·2d. per kW consumed for normal continuous operation.
0·85d. per kWh for off-peak usage.
Oil—13d. per gallon.
Coal—£7·5 per ton.
Steam—£20 per therm of M.D. plus 6·4d. per therm consumed.

CONCLUSIONS

For the ordinary run of commercial buildings of sizes in the range 200,000 to 500,000 cubic feet, off-peak directly embedded electrical floor-warming compares favourably in overall annual operating costs with any other form of heating. Although the ratio of the cost of electricity to that of an alternative fuel may be as great as 2/1, the considerable saving in capital cost of floor-warming as compared with other heating systems may more than compensate for this when overall costs are considered.

Where steady sources of low grade heat in the range 45 deg. Fah. and above are available, commercial use can be made of this energy by regrading the heat via a heat pump. The heat pumps investigated were largely in the experimental stage of development and the capital costs were consequently inflated. When running costs alone were considered, a heat pump using waste warm water as a source of low grade heat was 40 per cent cheaper than any other heating method. Off-peak use of heat pumps would improve their position in the table of overall costs.

TABLE III—*Performance of the Heat Pumps*

	Heat Pump *A*		Heat Pump *B*		Remarks
	1955–56	1956–57	1955–56	1956–57	
Operating Conditions					
Outside temperature (degrees Fahrenheit)					
Mean seasonal value	43·4	48·2	44·6	47·2	Continuous observation.
Minimum value	24·5	33	28	30	Continuous observation.
Mean inside temperature (degrees Fahrenheit)	69·2	70·5	64·4	69·8	Over season (taken only when heat pump operating).
Source temperature (degrees Fahrenheit)					
Mean seasonal value	72·9	72·9	60·0	59·2	Continuously recorded at entrance to evaporator.
Minimum value	62·0	48·5	48·5	42	Continuously recorded at entrance to evaporator.
Maximum value	83·5	93	68·0	71·0	Continuously recorded at entrance to evaporator.
Maximum hot water temperature (degrees Fahrenheit)					
Heat pump condenser	127	136	140	150	Continuously recorded.
Supply to building	115	114	124·5	125	Continuously recorded.
Efficiency of :					
1. Compressor and motor	81 per cent ±3 per cent	—	75 per cent ±5 per cent	—	—
2. Condenser	84 per cent ±5 per cent		—	—	—
3. Evaporator	106 per cent ±5 per cent	—	110 per cent ±5 per cent	—	Heat absorbed from condenser.
Performance energy ratio as percentage of Carnot performance $\left(\frac{T_1}{T_2-T_1}\right)$ (deg. K)	56 per cent 49 per cent	58 per cent 47 per cent	49 per cent 44 per cent	66 per cent 52 per cent	Heat pump only. With all pumps.
Energy Consumption of Heat Pumps					
Total annual consumption of heat pumps (C_2)	73,500kWh	70,000kWh	57,500kWh	62,900kWh	Thirty weeks.
Calculated annual heat requirement of building	489,000kWh	413,000kWh	158,000kWh	184,000kWh	Observed temperatures.
Overall seasonal performance energy ratio (C_1/C_2)	6·6	5·9	2·75	2·93	Includes all pumps.

Heavy Vehicle Refinement

SEVERAL of the more important models in the Leyland range of goods vehicles have now been redesigned, particularly with respect to the engine, transmission, and axles. The redesign has been based on the knowledge that heavy commercial vehicles, and the Leyland in particular, are to-day expected to have an overhaul life of 200,000 miles, so that innovations are restricted to features of established reliability. Hence, although the new models are equipped with "Power-Plus" versions of the previous engines, they are unsupercharged, because the service life of a turbocharger is believed to be shorter than that of the basic engine by a factor of about four. The new engines are three in number, an enlarged "Comet" of 400 cubic inches, and new versions of the O.600 and O.680; in the case of the O.600, a significant increase in torque has been effected, but the emphasis has been placed on efficiency, it being intended that the O.680 should be used in any application where an O.600 would be heavily loaded.

The basic engines will be familiar to our readers (see page 100, Jan. 20, 1956); modifications which effect all of them may be mentioned first. The bowl-shaped combustion chamber has been replaced by a toroidal one, which concentrates more of the air in the path of the four jets of fuel, and allows a brake mean effective pressure of about 120 lb per square inch to be achieved over a wide speed range. Consumption contours, which are not, we regret, available for publication, for the O.600 show the chamber to be extraordinarily well matched to its fuel injection equipment; the contours are roughly triangular, with the long sides parallel to the lines of constant rack setting, and the engine does not reach its smoke limit earlier at any particular part of the speed range. The innermost contour corresponds to 0·33 lb per horsepower-hour and covers a considerable area; in general, the engine is best driven at high torque, low speed, at least down to 1000 r.p.m. The compression ratio is 15·8 (16 on the O.400) and cold starting is effected without aids down to 20 deg. Fah. The engines are not stress or temperature limited.

Another modification effecting the piston is that wedge-section gas rings have been replaced by parallel section rings; a world-wide survey showed that detergent oils were universally available, and that ring sticking no longer determined overhaul intervals. Another change based on experience is that pneumatic (vacuum) governors have been abandoned, for a multiplicity of reasons: they were effected by oil vapour or dirt in the charge, they involved either different venturis for every different rating and air cleaner or adjustable (and maladjustable) throttle butterflies, the connections and linkages around the engine were exposed to ill treatment, and, of course, their stability was poor in both the short and the long term. Mechanical governors are preferred as next cheapest, but the O.600 and O.680 have hydraulic governors because a mechanical governor would be inadequate with the 10mm elements of the O·680.

Turning now to the individual engines, the O.400 "Comet" has a bore of 4·22in.; this increase in bore has forced the liner thickness down so that cast iron liners are no longer practicable, and steel liners, porous chrome plated, are fitted. It may be observed that it is not considered that a change to wet liners would evade the limitation on bore placed by the cylinder centre distance, since the minimum liner thickness, to be immune from corrosion accelerated by vibration of the liner, would be large. Each cylinder is surrounded by six ¼in high tensile studs with rolled threads for retention of the head, in which the exhaust ports are now on the opposite side to the inlets; this is possible on the "Comet" since it does not use a remote control gear change and hence engine width is less restricted. Fuel is supplied by a Simms "Minipump" to Leyland four-hole injectors.

The "Powerplus" versions of the O.600 and O.680 are also recognisable by their manifolds, there being two intake manifolds, with individual paper filters, above the exhaust manifolds; the engines are now installed with intakes in regions of cold air. The heavy-vehicle engines have a closely-fitting shroud about the fan, to prevent air recirculating through the fan without passing through the radiator. The fan runs whenever the engine is running and to replace a fan belt the shroud must be removed. One noteworthy detail of the biggest engine is its speed range of 6 : 1.

The principal data of the "Powerplus" engines are given in the table following.

TABLE

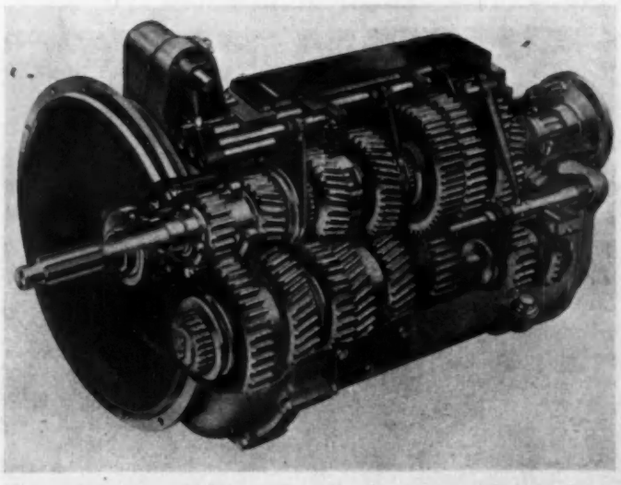
Characteristic	Engine		
	O.400	O.600	O.680
Bore and stroke, in...	4·22 by 4·75	4·8 by 5·5	5 by 5·75
Swept volume, cubic centimetres... ...	399	597	677
Swept volume, litres	6·54	9·8	11·1
Gross horsepower ...	131 at 2400 r.p.m.	146 at 1700 r.p.m.	210 at 2200 r.p.m.
Net horsepower ...	125 at 2400 r.p.m.	140 at 1700 r.p.m.	200 at 2200 r.p.m.
Maximum b.m.e.p., lb per square inch	114 at 1600 r.p.m.	111 at 1200 r.p.m.	122 at 1200 r.p.m
Idling speed, r.p.m....	400	400	350
Weight, with starter and generator, lb	1181	1808	1840

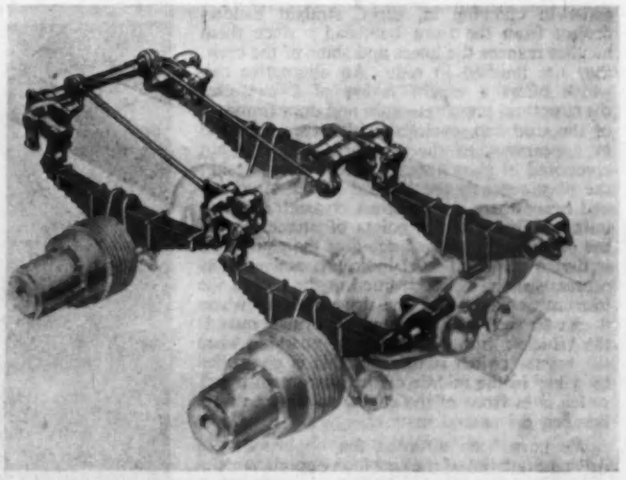
The larger engines have 16½in clutches, all parts except the springs being common; in order to render the operating forces similar, the O.680 is normally installed with an air servo motor boosting the clutch hydraulic system. No clutch stop is provided.

A new gearbox has been introduced to accept all of and more than the output of the up-rated engines. It is of classical conception, basically a five-speed box, but either or both of two extra trains can be fitted; one is an overdrive sixth, and the other an alternative set of "constant mesh" gears, straight cut instead of helical, which is intended to provide a crawler first and reverse but can be engaged or discarded regardless of main gearbox selection by a separate lever. All gears except reverse are engaged by dog clutches, the clutches being "locked" against disengaging under load: this is achieved by making the male members of the clutches with teeth slightly wider over the end sections, and cutting away the female so that when advanced to engage a gear, the wide teeth are free to move across and baulk any tendency for the clutch to move axially. The shift pattern is perfectly regular (all "even" ratios in front and one selector to the right of preceding "odd" ratio) and the intervals, changing down, are 1/0·766=1·3, (fifth), 1·69, (fourth), 1·63, (third), 1·68, (second), 1·57, while the alternative constant mesh gears lower any ratio by 1·29. The box is lubricated by its own pump. Provision is made for two power take-offs, one of them rated for 100 per cent power.

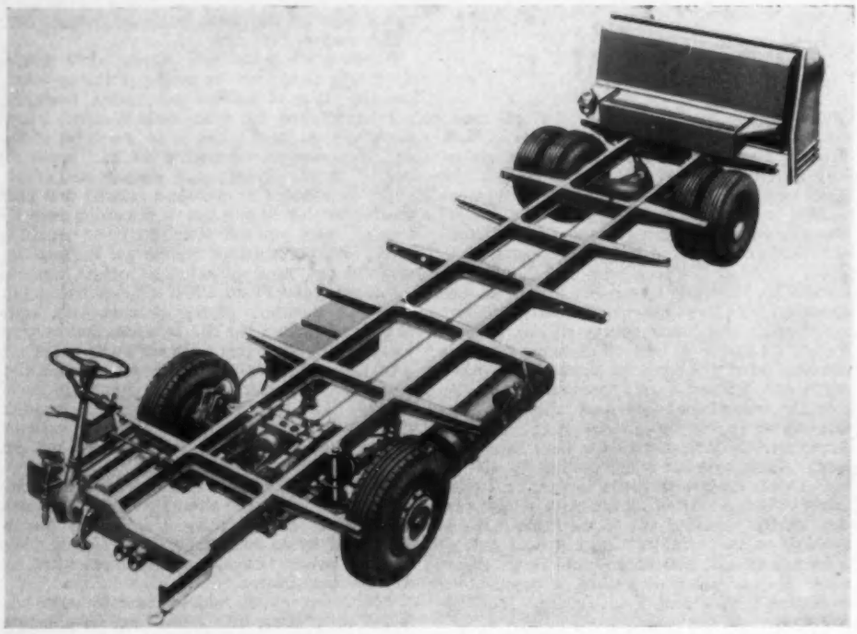
The heavy goods vehicles have hitherto had worm drive axles, with a two-stage bevel-helical axle as a heavy-duty alternative (see page 658, Apr. 15, 1960). A wormwheel large enough to accept the torques imposed on "Powerplus" vehicles could not be accommodated, so that a two-stage axle became virtually inescapable, and it was decided to change to a hub-reduction design as already used on Albion and "Comet" vehicles (see page 188, August 1, 1958). The torques on the right-angle drive were thus reduced to a magnitude easily handled by a spiral bevel; where two axles are driven, the first has a pair of bevels of opposite hand and is driven from the third differential by a 1·1 helical train. Some indication of the size of these components is given by the fact that the interchangeable trailing axle is 7 cwt. lighter.

The "Hippo" and "Octopus" are now available with a new rear suspension geometry which balances the axle loads in the presence as well as the absence of braking and driving torques. The principle can be followed in our illustration, from which it will be clear that the two axles are located by identical and not mirror-image linkages and so asymmetrical loads will not upset the balance. It can be seen that this suspension will be severely loaded if the two axles roll in opposite directions, and, therefore, for use other than on highways the previous suspension, with but one spring each side mounted on the chassis on a rubber bushing, is recommended; this suspension has been improved by forming the ends of the main leaves into part-spherical pads instead of eyes and





(Left) Six speed (direct fifth) gearbox with alternative constant mesh trains: the dog clutches in front of the lay shaft engage the low train and other dogs behind the helical gear engage the main train. (Right) The non-reactive load balancing suspension on a double drive vehicle; there can faintly be seen the housing for the third differential and helical gear train on the first axle. The large hubs house five-pinion fixed-annulus epicyclic reductions.



The " Lion " single-decked passenger chassis ; the front axle is located by leaf springs and to give constant step height, air bellows. The frame is flat-topped save for a slight rise over the front axle

using the springs to take only the vertical and side forces. The rear axles have a design load of 9 tons and are matched by a new 5-ton front axle ; tyres are 10·00×20, fourteen ply rating, on the " Beaver," which uses the full axle design loads for a gross weight of 14 tons, and also on the 20-ton gross " Hippo," but the " Octopus " has 9·00×20, twelve ply rating tyres. (Export models, 11·00×20, twelve ply.)

The revised heavy vehicles have a Bendix-Westinghouse air brake system with 15½in drums previously used on the " Super Comet " and some p.s.v., designed to effect 0·6*g* at 60 lb per square inch. The single-pull handbrake is assisted by an air cylinder.

Power assistance, in this case hydraulic, is also standard for the steering. The column is connected through a control valve to a Marles cam-and-double-roller gear with a ratio slightly lower than standard ; the ram acts on the drop arm or, for the twin-steer " Octopus," the relay drop arm. The fluid reservoir is located near the driver's seat, where the contents can be checked by removing the cap.

Some interest attaches to the cab now standardised. It remains the basic Motor Panels product, but the form with deep doors previously used by Albion has been adopted ; there are two steps to choose between when entering. To assist in climbing in, short, straight handles project from the front bulkhead ; since these handles menace the knees and shins of the crew, they are finished in red. An alternative cab which offers a weight saving of 2 cwt uses the structural pressings—sub- and door frames—of the steel cab, enclosed with panels identical in appearance to the standard steel cab but composed of glass fibre reinforced epoxy resin ; the plastic panels are bonded to the structure, and hence there are no stress concentrations to initiate failures at the points of attachment of the plastic. An unusual detail of the equipment is that a sump oil level indicator, activated by a press switch, has been fitted at the end of the instrument panel near the driver's door, where it can be seen and operated by a man outside the vehicle ; however, it is only operable when the master switch is on, and this is controlled by a key in the middle of the instrument panel, which is in front of the engine cowling halfway between driver and mate.

We have been afforded the opportunity of driving examples of the new heavy goods vehicles over the Leyland test track. The new gearbox is, by virtue of the consistent intervals between ratios, easily learnt, and changes quickly enough for upward shifts to be possible on a faint adverse gradient despite the absence of a clutch stop. The power steering calls for little effort, but on an articulated vehicle—the tractor has a wheelbase of 8ft—the inch or two of free travel introduced by the valve tends to cause the driver to proceed in a series of shallow curves rather than a straight line. On a rigid vehicle it is obtrusive that the ratio is almost as low as on a vehicle with a manual system ; because of the " rationalisation " between models, the steering wheel remains in the shallow inclination for maximum torque. The new braking system calls for only moderate pedal forces, but does not commence to act until a quite significant force has been applied ; the effect is as if an extremely strong pedal return spring were fitted.

The designation " Lion " has been revived for a new passenger vehicle, a single-decked version of the " Atlantean " in its beam-axle, production form, which is in essence an enlarged rear-engined " Cub " (see page 339, September 7, 1956). A single-decker uses a rear-mounted engine not to save overall height but for quietness and ease of access, and this engine position is well established in the United States of America, for which country the 200 h.p. chassis to be seen at the forthcoming Commercial Motor Show is destined. In broad principles it follows the " Worldmaster " coach design, but instead of the engine being horizontal it is vertical ; hence there is a bonnet at the back, as on so many Continental rear-engined coaches, and the length of the saloon is restricted.

The " Lion " has a wheelbase of 20ft and is designed for a body of 34ft length ; the width and nominal height of the frame are both 34in. The frame is straight-topped except for a 3in rise over the front springs ; this gives clearance enough for air springs to be included (front axle only) if desired. As indicated above, the vehicle is supplied in chassis form ; it is not designed to be stiff in torsion. Either O.600 or O.680 engines can be fitted. It is intended that the body shall incorporate a duct in the roof to carry clean air from high up at the front of the vehicle to the rear, where a multi-element cyclone filter (not self-emptying) is installed.

Mobile Service Training Unit

Six mobile training units are being introduced by the service organisation of the British Motor Corporation, Ltd., at Cowley, Oxford, for the instruction of dealers' staff in maintenance methods and equipment. This scheme extends to dealers facilities for training similar to those at the permanent schools which hitherto, for reasons of accommodation, have had to be restricted to employees of distributors.

One of the vehicles built for this purpose by Marshall Motor Bodies, of Cambridge, to a design prepared by a B.M.C. body drawing-office, is illustrated. It is powered by the B.M.C. 5·1 litre diesel engine and built on a long-wheelbase coach chassis having a 25in extension, making a total wheelbase of 17ft 1in. Length from front to rear bumper is 30ft, overall width 8ft, and overall height 9ft 9in. Equipment includes a five-speed gearbox, two-speed Eaton axle and air brakes.

The instruction facilities are arranged to cover both s.i. and c.i. engines, those appliances which are not removable being protected by covers when not in use. Service tools are mounted in tool boards which are stored during transit in compartments in the side of the vehicle, below

Mobile unit for servicing instruction at motor dealers' premises

floor level. Boards required for demonstration are clipped to the walls of the school compartment in the body. This portion of the vehicle is 17ft 6in long, 7ft 2in wide and has a maximum internal height of 6ft 4in.

Fluorescent lighting, a 3kW "Frigidaire" air-conditioning unit and the 1½ h.p. motor driving a Merlin "Calimaster" for diesel-engine injection equipment are supplied from local mains, but emergency lighting here and in the cab is taken from the vehicle battery. Among other appliances are nozzle test equipment, a Crypton "Motormaster" engine performance analyser, and filmstrip projector. It is expected that classes of up to twelve persons at a time will be dealt with in five-day courses. The schools will stay at a centre for two weeks or more if necessary. The programme of instruction is completely flexible in order to allow time for discussion of individual problems which service staff may have met in the course of their work. At first the schools are operating in the United Kingdom, but later the service will be extended on a world-wide basis.

Further Truck and Tyre Evolution

THE forward control vehicles of the Bedford range have now been provided with full forward control cabs, while retaining their vertical single-bank engines. The new cab is only about 3in longer than the old, and has a shelf behind the seats large enough to provide a man of average height with a bed.

In contrast to many full-forward-control vehicles not using horizontal engines, the cab does not tilt : access to the engine for routine servicing is behind the wheels, under propped upward-opening doors, while to reach the top part of the engine, where the belt-driven fan is, there is a screw-down panel in the shelf supporting the seats. It is claimed that the entire cab can be removed in thirty minutes. The cab does not extend to the full width of the vehicle, but is wide enough for a passenger seat accommodating two persons ; the step height is 19in to 22in, and access is virtually equally easy from either side.

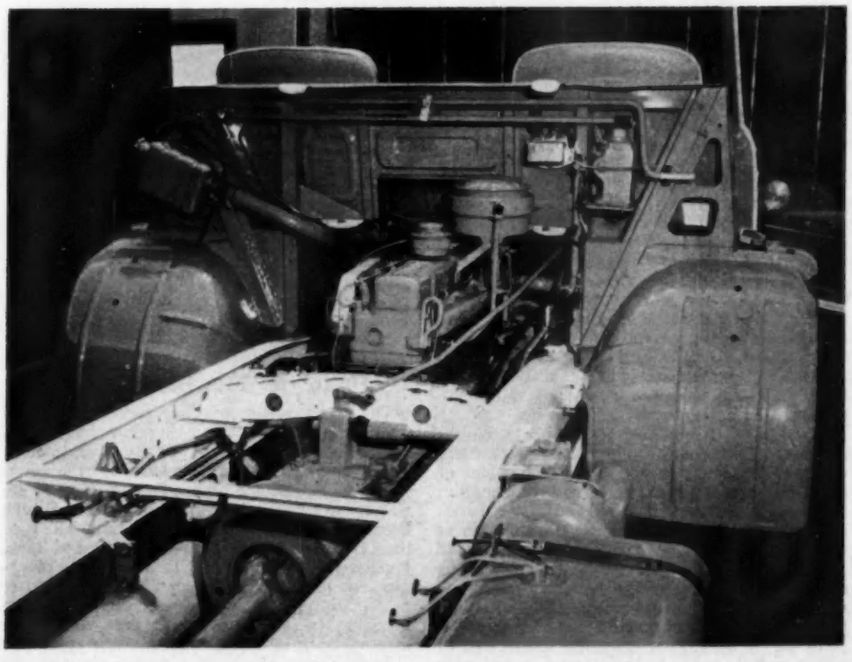
The new vehicles, identified as the "TK" range, are noteworthy for being based on tyres of modern design and performance. The 7·50 × 16 size which has been standard on the 4-ton Bedford (see "Truck and Tyre Evolution," THE ENGINEER, September 12, 1958) has now been extended to the 5-ton vehicles, using tyres of radial cord construction in steel, built by or under licence from Michelin Tyre Company, Ltd. ; thus the loading height of the 5-ton vehicle, nominally 42½in, compares with that of the 3-ton and 4-ton vehicles, 41½in. It is of interest to note that when steel cord tyres are used on the 4-ton vehicle, a 7·00 × 16 tyre is now the alternative to the textile of ten ply rating. Similarly, the 6-ton chassis is available on 8·25 × 17 steel cord tyres as an alternative to 7·50 × 20 textile tyres, saving 1½in in height. Apart from the obvious advantages of steel cord tyres, it is pointed out that an individual casing will accept retreading more times.

The new vehicles, which range from 3-ton trucks to 10-ton tractors, have a choice of two or more engines out of five ; the four cylinder 200 cubic inch diesel, and the six cylinder 214 cubic inch and 300 cubic inch petrol and 300 cubic inch and Leyland 350 cubic inch diesels—a 12-ton tractor invariably has the Leyland engine. Modifications principally affect the cooling system ; as the radiator is low down under the cab floor, a separate header tank is fitted, and this is arranged to include a condenser tank connected to the engine by a syphon, so that moderate boiling does not involve loss of coolant. The engine mountings are in all cases of the Leyland pattern, two inclined rubber-bushed links picking up the clutch housing. The gearboxes are either four-speed Bedford, synchromesh except with the 214 in petrol engine, or five-speed David Brown ; the remote control is on the lines familiar on light vehicles with three selectors, with separate linkages transmitting sideways and longwise movements of the lever—the effect is that the neutral leg of the "gate" seems shorter and the gear legs far longer than usual. This result may be attributable to the flexibility of the engine mountings ; the clutch pedal also has been endowed with a long travel, and the throttle linkage is supported from a stay articulated to the engine.

Behind the gearbox is mounted a transmission brake, applied by a short, convenient lever on the right of the driver ; the brake itself is drum on the lighter and disc on the heavier models, and is designed to make three stops of a laden vehicle before encountering fade. This independent handbrake forms a safeguard against over-heating of the drum brakes on the wheels, while the use of a tandem master cylinder with mechanical linkage from the pedal ensures that no single hydraulic failure can affect both front and rear brakes. Servo assistance is vacuum on petrol and compressed air on diesel vehicles ; a full reservoir will give three applications after the engine has stopped.

The Bedford full forward control cab is fixed, and access to the power plant is gained through the rear quarters and a small panel between the seats

The relatively far aft mounting of the engine has resulted in the rear tyres being more heavily loaded than the front, with 71 per cent of the fully loaded weight ; braking is 50 per cent on each axle. The increase in rear axle loads has caused the 11,400 lb axle of the normal control vehicles to be uprated to 14,000 lb, by increasing the axle tube thickness and changing the bearings, for use in the 3-ton, 4-ton and 5-ton vehicles. An 18,000 lb single-speed axle for the 7½-ton truck uses the bearings of the two-speed axle of the same rating.



A "TK" vehicle in chassis-cowl form ; visible are the radiator below the seats, and the header/condenser tank high on the bulkhead. This example has the 300 cubic inch oil engine, but the drum transmission brake used at lighter vehicle weights. Details of interest are the inclined links carrying the bell housing from the cross-member, the two separate linkages of the gear shift mechanism, the complexity of the throttle linkage, and the plugs for disconnecting the electric wiring when the cab is to be removed

Signals via "Echo" Satellite

A TEAM of scientists from the Post Office and the Royal Radar Establishment, Malvern, succeeded on the evening of Monday, August 29, in receiving at Malvern signals which were transmitted from the Bell Telephone Laboratories, New Jersey, and reflected from the satellite "Echo 1." The signals included unmodulated carrier waves and speech transmissions. The satellite, to which we referred in our August 19 issue, page 300, is a 100ft dia. balloon coated with a thin film of metal in order to reflect radio waves, and has been orbiting around the earth since Friday, August 12. The orbit is at a height of about 1000 miles and the satellite takes approximately two hours to make one complete circuit of the earth. Professor Lovell, of the Jodrell Bank Radio Astronomy Station, has announced that signals from New Jersey were received about a week ago using the 250ft radio telescope. The tests at Malvern are of particular interest in that the radio aerial used was only 20ft in diameter.

SHORTER REPORTS

Natural Resources in Scotland

A THREE-DAY symposium, to be held from October 31 to November 2, has been arranged by the Scottish Council (Development and Industry) at which authorities on resources will meet for discussion and the interchange of ideas. The first day of the meeting will be devoted to papers covering basic resource facts, soils, minerals, surface and underground water, fish- and wild-life, and marine resources. The utilisation of resources will be dealt with on the second day when papers presented for discussion will cover multiple land use, water use, fuel and energy, utilisation of minerals, and biological resources. The third day will be concerned with resource administration and development, and papers have been arranged dealing with human resources and the mechanics of resource development.

The symposium, at which fifty papers are to be presented, is intended to form a fact-finding group, the Council states, from which should come pointers to future action of advantage to the Scottish economy as a whole. It is intended to be the first step in an inquiry which may be expected to extend over a period of four years.

It will be recalled that the Scottish Council's Committee on Natural Resources in Scotland was formed early in 1959 under the chairmanship of Mr. L. A. Elgood.

Synthetic Rubber Developments

Two years ago the first British plant for the bulk production of synthetic rubber came into production at Hythe, Southampton. Built for the International Synthetic Rubber Company, Ltd., the plant was originally designed for an output of 70,000 tons of synthetic rubber a year. In its original form the plant was the subject of an article in THE ENGINEER of November 7, 1958 (page 733). Since the opening date considerable extensions and changes have taken place, and production is now at an annual rate of about 80,000 tons ; this figure is being raised to 90,000 tons in the near future. Production already exceeds the present United Kingdom consumption rate, and a proportion of the output is available for export. Steps are being taken to expand the overseas business, and the company has a technical service section which advises on existing and possible new uses for its products, at home and abroad.

The principal new development at Hythe is the introduction of plant for producing high solids styrene butadiene rubber (S.B.R.) latex. Synthetic rubber latex with a low solids content is produced as part of the process for the manufacture of solid S.B.R., and there are several ways in which lattices with a high solids content can be produced. Using plant of their own design, International Synthetic Rubber are now concentrating their low solids latex to produce a high solids content material, the solids being in excess of 62 per cent.

This product, though it was designed principally for the manufacture of foam rubber, is also finding considerable application in other fields, such as carpet backing, the impregnation and coating of board and other fibres, and in a wide range of dipped goods and adhesives. Foam produced with 25 per cent of synthetic latex has met the specification of the Society of Motor Manufacturers and Traders in Great Britain. In the U.S.A. latex foam blends of 60/40 S.B.R./natural rubber are common and 100 per cent S.B.R. is not unusual. United Kingdom consumption of S.B.R. latex in 1959 was under 1000 tons, but it is estimated to be running at a rate of more than 5000 tons by the end of 1960. This figure is likely to increase considerably.

To enable it to produce either solid rubber or high solids latex as required, the company has modified its plant by providing new latex storage facilities. By this means the two production processes, which both start with the proportioning and mixing of two main ingredients, styrene and butadiene, together with certain other chemicals, can be dovetailed.

In addition to new production plant a large technical service laboratory is now in operation at Hythe. This laboratory, working in conjunction with the sales development section, is responsible for investigation of possible new and future uses for synthetic rubber. A typical item at present under development is a chair pad for railway track.

U.R.S.I. Meeting in London

THE thirteenth General Assembly of the International Scientific Radio Union (U.R.S.I.) is being held at University College, London. Sessions will continue until September 15. At the opening planary session, held in the Friends Meeting House, Euston Road, on September 5, the president, Dr. L. V. Berkner, spoke of the union's keen interest in space research as a result of its predominant interest in the ionosphere, and the exosphere. To deal with the unions iterim interests in this field, he had appointed two *ad hoc* committees, one on Space Radio Research under the chairmanship of Professor Len Huxby, and one on Space Radio Relay under the chairmanship of Professor Samuel Silver, to study U.R.S.I. interests in this growing field of activity. These committees had held meetings and drawn up a programme which would be presented at a special half-day scientific session of the full assembly.

During the last triennium, the president continued, the allocation of protected radio frequency channels for use by radio astronomy had been a matter of major concern to the U.R.S.I. The problem of radio interference to radio astronomers had always been very serious. With the coming of artificial earth satellites in a variety of forms and their associated radio transmissions, this problem was enormously accentuated. The steady growth in utilisation of the radio spectrum was now threatening the very existence of radio astronomy as a science able to achieve penetration to the limits of our universe. Consequently, U.R.S.I. had expended great effort in acquiring the protection necessary for a healthy science of radio astronomy. At Los Angeles in 1959, the C.C.I.R. for the first time adopted resolutions looking to the protection of specific frequencies for radio astronomy. National committees of the U.R.S.I. had conveyed to their representatives at the Geneva meeting of the International Telecommunications Union, in the same year, the urgency of protection for this science. As a result, resolutions were adopted for the first time at a general conference of the International Telecommunications Union which recognised the right of radio astronomy to some measure of protection. Unfortunately, these measures were not yet adequate and there remained an immense task ahead.

In addition to the problem of protection of channels for radio astronomy, they were faced with new problems involving the assignment of radio channels for space research. Information from space vehicles required adequate bandwidth and protection to permit transmission at reasonable rates over distances many orders of magnitude greater than the dimensions of the earth. Thus, their union had a growing responsibility for the basic protection of radio frequency channels imperative for the advancement of a variety of scientific researches, of which radio astronomy and space radio were examples.

As a consequence of this new responsibility, the president had proposed a special inter-union committee on the allocation of radio frequencies for scientific purposes, of which the U.R.S.I. would be the parent union, and it was his hope that the U.R.S.I. could take the necessary steps at this General Assembly so that final action would be approved by the International Committee of Scientific Unions at its meeting in Lisbon in October.

The work of the present assembly is divided among seven commissions, dealing with radio measurements and standards, radio and the troposphere, ionospheric radio, radio noise of terrestial origin, radio astronomy, radio waves and circuits, and radioelectronics. All commissions are joining in a session today, September 9, on radio studies in space research.

Leak Detection with Radio-Isotopes

A METHOD for detecting leaks at a rate of less than one sixty-millionth part of a cubic inch a day will be illustrated in the United Kingdom Atomic Energy Authority's exhibit at the Fifth International Instruments and Measurements Exhibition in Stockholm (September 10–17). The method, which uses a radioisotope technique, has been developed by the U.K.A.E.A. Wantage Research Laboratory.

A sixty-millionth of a cubic inch (a cube of 0·0025in side) can contain 7,000,000 million atoms of the radioactive gas used in this particular application. Since, initially, some 16,000 of these atoms would decay and emit tell-tale radiation each second, detection of their presence and calculation of the rate of leakage can be carried out with comparative ease.

To determine the rate at which leaks in sealed components would admit air or other gases, these components are immersed in an atmosphere of radioactive krypton-85 gas which is raised to a known pressure for a fixed period. After the components have been removed from the gas, the amounts of krypton which have found their way into the objects under test are determined by measuring the emitted radiation with a counter.

For outward leakage, the component is filled to the required pressure with a known specific activity of the gas. Then, either the escaping gas is collected and assayed with a counter, or measurements are made of the decrease over a period of time in the intensity of radiation emitted from the component. The latter is the most reliable method as a leak can become temporarily blocked.

Tests of small articles such as transistors—whose life is shortened if oxygen or water vapour penetrates their containers—are best made by immersing them in the gas. Sensitivity is reported to be about 100 times better than with a helium mass spectrometer.

[Reply Card No. E4384]

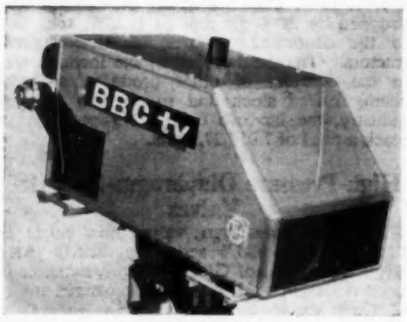
Prototype Television Camera

THE conspicuous rotatable turret carrying a selection of fixed-focus lenses which has been a characteristic of television cameras is replaced in the prototype (illustrated opposite) by a zoom lens recessed into the body. Development of the new camera has been carried out by the British Broadcasting Corporation in collaboration with the Taylor, Taylor and Hobson Division of Rank Precision Industries, Ltd. In addition to providing a more compact camera, with better protection against damage to the lenses, the recessing of the first lens makes a separate external hood unnecessary.

Light enters the optical system through the aperture in the front of the camera body. Having passed through the main lens system to the back of the camera, the light is reflected through a right angle and passed through an assembly into which one of four neutral density filters and one of four

colour filters, mounted on rotable carriages, can be introduced. The light is then again reflected through a right angle and enters the camera tube which is fitted, facing backwards, within the lower left-hand side of the camera, as seen in the second illustration.

The lens system comprises a Taylor, Taylor and Hobson "Varotal" III zoom lens together with a wide angle adaptor which can be introduced in front of the main lens to give four focal length ranges : (1) 2in to 10in at f/4, minimum focusing distance 2ft 6in ; (2) 4in to 20in at f/8, minimum focusing distance 2ft 6in ; (3) 4in to 20in at f/4, minimum focusing distance 12ft ; (4) 8in to 40in at f/8, minimum focusing distance 12ft.



Television camera with zoom lens assembly and wide-angle adaptor built into body

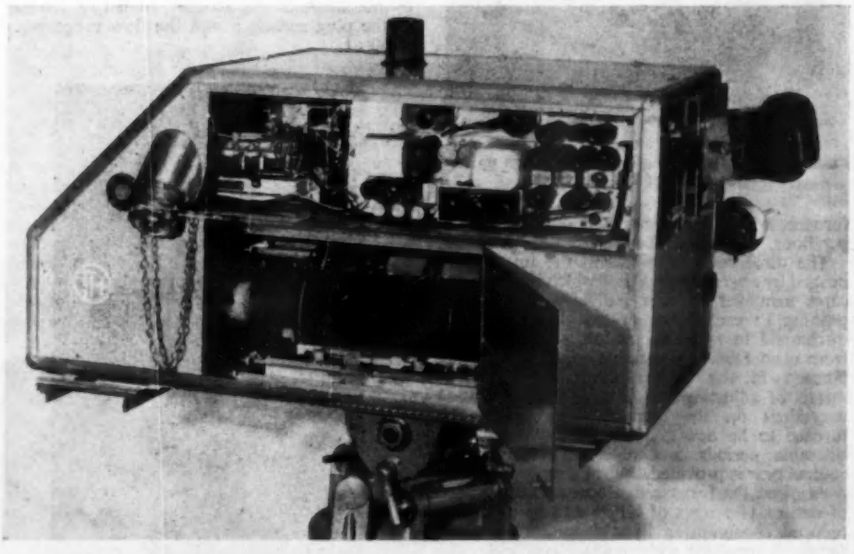
The change from range 1 to range 2 and from range 3 to range 4 is effected by an "optical switch" which can be operated while the camera is on transmission. This device alters the relationship of the moving elements of the zoom to cover the two ranges. The change from ranges 1 and 2 to ranges 3 and 4 is made by traversing the wide angle adaptor to the right, out of the optical path, by a mechanism controlled from the back of the camera. By the inclusion of this adaptor, the camera has a wider range of application than earlier instruments with zoom lenses, which had not a sufficient range of viewing angles to render the use of a selection of fixed focus lenses unnecessary.

A feature of the lens which makes it specially suitable for this application is the long back-focus distance of about 11in. It is this characteristic which has made it possible to fold the optical path as already described, and as a result the camera tube yoke lies alongside the lens assembly. This compact layout considerably reduces the overall length of the camera as compared with the conventional in-line arrangement.

The mirrors used to fold the beam from the lens to the camera tube, as described above, have layer reflecting surfaces which, in conjunction with the colour filters, give the required overall colour responses. Referring to the first illustration, the handle at the rear of the camera body adjusts the moving element of the zoom assembly, and the focus control is mounted on it so that the two can conveniently be adjusted together. Adjacent to these controls are those for filter selection and the optical switch lever is located towards the front of the control panel.

Electronic components of this prototype camera are those of the Marconi Mark III image orthicon ; it can thus be used with many of the B.B.C. television outside broadcast and studio equipments in place of one of the conventional cameras. This "universal zoom" camera has been constructed so as to assess its value under operational conditions both in studios and on outside broadcasts. If its characteristics are found adequate and useful, further cameras could be constructed which would be smaller, cheaper and lighter.

[Reply Card No. E4385]



Camera interior, showing electronic chassis and image orthicon tube facing towards rear

Fault Monitor for Floor Warming Cables

A FAULT monitor which will immediately detect any damage to heating cables during the installation of solid embedded floor warming systems has been developed by the "Panelec" Heating Division of British Insulated Callender's Cables, Ltd., 83–86, Saffron Hill, London, E.C.1. By means of a bell and indicator lights, this fully transistorised electronic device gives visual and audible warning of insulation or continuity failures on any make of cable.

The instrument, which is portable, weighs 8½ lb and is contained in a grey mottle enamelled sheet steel case, measuring 10¼in by 4¾in by 3¾in, fitted with a leather carrying handle. It is a composite, self-contained unit operating on readily obtainable dry batteries, one 33V and two 6V, with an approximate working life of 120 to 150 hours. Three XB103 transistors are incorporated, providing a high degree of sensitivity normally only expected from valve type instruments.

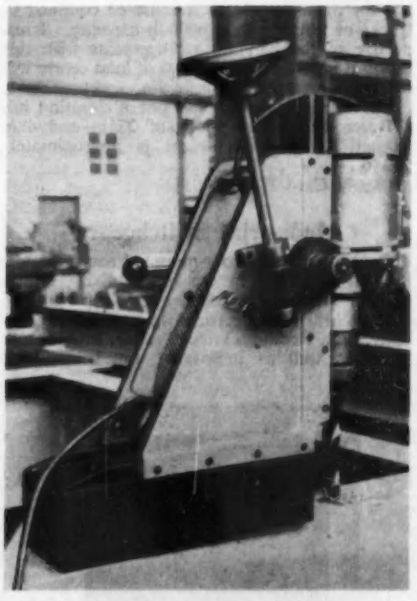
Any number of cables may be monitored simultaneously, providing the total resistance of the cores does not exceed 1000 ohms. The cable cores are connected in series and the two free ends attached to two terminals marked "Cable." A third terminal is then connected to a temporary earth electrode buried in the wet screed or, if a screened type cable is being installed, to the screen. There is a combined on-off and three position selector switch. With the switch in position "A," dummy faults are placed in circuit, thus enabling the calibration of the instrument to be checked before it is used. When this check has been completed the instrument is brought into action by moving the switch to the "Monitor" position.

If the insulation resistance of any cable now falls below 5 megohms to earth, or if the core resistance rises to above 1000 ohms, the bell will ring and an indicator light will show the nature of the fault, continuing to operate even if the fault clears itself. Should an internal breakdown develop while the monitor is in use, it will "fail to safety," that is, a fault will be indicated by the bell and light. Where a cable is damaged while monitoring, the instrument may be used as an indicator merely by moving the switch to position "B." The bell and lights will then operate only while the fault is present and will cease as soon as the fault is cleared or disconnected. By connecting the individual cables in turn, the impaired unit can be found rapidly, and repaired or replaced.

[Reply Card No. E4391]

Magnetic Drill Stands

A RANGE of magnetic drill stands, for use with portable machines having capacities for drills up to 1¼in diameter now, made by Magco, Ltd., Porchester, Hants., can be placed anywhere on a steel plate or other magnetic material to enable drilling operations to be carried out *in situ* on large work or in awkward situations. Each of these drill stands, one of which is illustrated, comprises a magnet base with a column carrying a slide for the mounting of a portable pneumatic or electric drill. The drill carriage is fed through a rack and pinion operated by handwheel through worm gearing at the side of the column.



Magnetic drill stand for ¾in capacity portable drilling machine

When the stand is first placed on the job to be drilled and plugged into the mains supply a weak field is induced in the magnet by operation of a variable rheostat. This lightly holds the stand in position but leaves it sufficiently movable to position the drill accurately in respect to the work. Full magnetic force is then induced by turning the rheostat control to full power, when the stand is rigidly clamped in position ready for drilling.

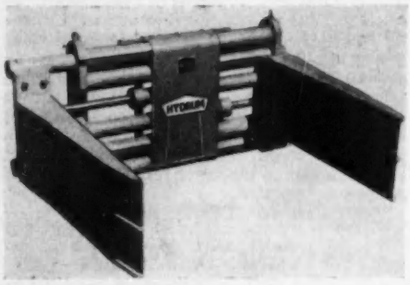
[Reply Card No. E4392]

SHORTER REPORTS *(Continued)*

Fork Truck Load Clamps

AN addition to the range of " Hydrum " load clamps made by R. H. Corbett and Co., Ltd., Rochester, Kent, is rated for 6000 lb at 24in from the bridge plates of the clamp, and its widths of opening are from 20in to 75in. The clamp has double acting rams of 3in bore and 27½in stroke and operates with a working pressure of 2000 lb per square inch.

The clamp is intended to cover a load range of



Load clamp, rated at 6000 lb at 24in from the bridge plates, fitted with general purpose arms

slightly above 4000 lb to 6000 lb and it can be used on a truck of less than 6000 lb capacity when dealing with loads at the lower end of this scale, but for maximum loads it must be confined to trucks of not less than 6000 lb capacity. Irrespective of the hanging arrangements with this clamp it is stated that the loss of load centre will never be greater than 8½in to 9in.

The clamp to be seen in our illustration has a frame height and width of 32½in and 48in respectively and its weight is approximately 900 lb.

[Reply Card No. E4401]

Industrial Switchgear

OPERATION by a front-mounted rotary handle has been adopted in the new " Exel " range of 500V industrial switchgear now in production by the Midland Electric Manufacturing Company, Ltd., Reddings Lane, Tyseley, Birmingham 11. As well as improving appearance, this

Switch fuse with front-mounted operating handle

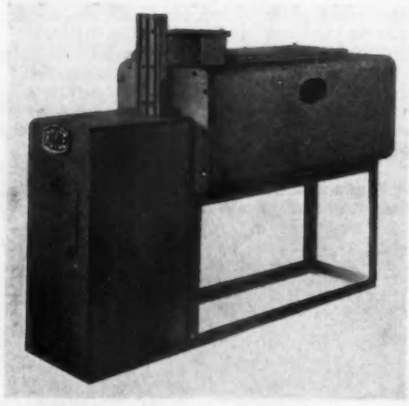
arrangement, seen in the accompanying illustration, allows more compact assembly on switchboards and panels. The " Exel " switches and switch fuses are contained in fabricated cases of heavy gauge sheet steel with hinged covers, rustproofed and finished grey stove enamel, with chrome-plated switch handles.

The new " Kantark-Exel " fuse bases in this switchgear will accommodate either semi-enclosed rewirable or h.r.c. cartridge fuse carriers. With the steadily increasing load in the large industrial areas, the point can soon be reached where the damaging effects of short-circuit fault current may exceed the rupturing capacities of most semi-enclosed rewirable fuses. It is therefore the maker's policy that all new M.E.M. 500V switchgear and fuseboards shall accept either rewirable or h.r.c. fuse carriers without increase in price. The " Memrex Senior " range of weatherproof switchgear has been redesigned to take h.r.c. " Kantark-Exel " rewirable fuses, which will also accept h.r.c. cartridge fuse links to B.S.88, Appendix J, dimensions.

(Reply Card No. E4402)

Slug Heating Furnace

A SMALL continuous furnace for the preheating of non-ferrous billets and slugs suitable for delivering to a press has been developed by Royce Electric Furnaces, Ltd., of Albert Drive, Sheerwater, nr. Woking, and is shown in our illustration. It is designed to accommodate three rows of billets, which may be up to 1in diameter and nominally 1in long. Temperatures up to 900 deg. Cent. can be attained in the



Pusher furnace for heating non-ferrous slugs up to a temperature of 900 deg. Cent.

furnace, which has a designed output of 50 lb per hour, or equivalent to 240 billets per hour.

The three rows of billets in the furnace are pushed by a synchronous gear which incorporates cams arranged to give individual consecutive pushing to each tube, so that hot billets are discharged in rapid succession, one at a time, from each tube. A variable speed gear incorporated in the pusher mechanism provides means of adjusting the heating time. Loading magazines on the entrance end enable the furnace to be operated automatically for considerable periods and automatic temperature control gear is provided. When a reduced output is required the furnace can operate with a feed of one or two rows of billets and to cover the reduced consumption in such cases the transformer is provided with reduced tappings.

[Reply Card No. E4403]

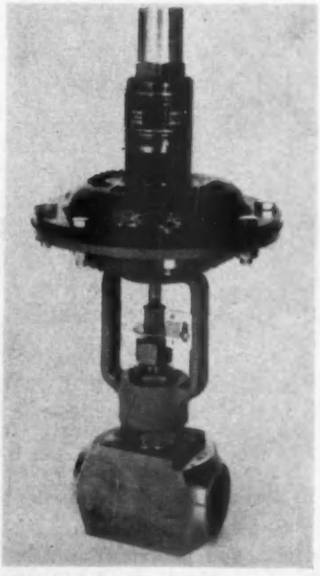
Oil Consumption in Great Britain

STATISTICS issued by the Petroleum Information Bureau indicate that in the first half of this year oil consumption in this country rose by 18·7 per cent, compared with the corresponding period in 1959, to reach a total of 21,209,272 tons. Within this total, fuel oil deliveries amounted to 8,860,106 tons, an increase of 29 per cent, while those of gas/diesel oil increased by 10 per cent to 1,767,923 tons. Consumption of motor spirit was substantially higher at 3,636,905 tons, compared with 3,351,390 tons in 1959, although there was a drop in the amount of standard grade used and also in deliveries to commercial customers. The latter is mainly due to the increase in diesel-engined vehicles and this was reflected in the increase of 14·6 per cent in the consumption of D.E.R.V. fuel to a total of 1,251,816 tons. Deliveries of burning oil also showed a small increase of 2·6 per cent to 715,855 tons, while vaporising oil consumption dropped by 22·4 per cent to 162,743 tons due to the continued turnover to diesel-engined tractors. The greatest percentage increase was in the category of other products, such as chemical feed stock and supplies to the gas industry, the increase being 62·9 per cent to reach a total of 1,057,272 tons.

High-Pressure Diaphragm-Operated Valves

DIAPHRAGM-OPERATED valves now made in the " Uniflow 800 " series by British Arca Regulators, Ltd., of Gloucester, are available in sizes from ¼in to 1in and for pressures up to 60,000 lb per square inch. These valves, of the direct or reversing acting design, are intended for service in the petroleum, chemical and process industries and are suitable for operation with a wide variety of semi-corrosive media. They are available with bodies of steel, stainless steel, brass, aluminium, and a number of other alloys for corrosion or erosion resistant service. The standard body pressure ratings are : steel 15,000 lb per square inch, stainless steel 5000 lb per square inch, and brass 800 lb per square inch. Special bodies for 60,000 lb per square inch, with high-pressure tube connections, can also be supplied. The body patterns include angle and three-way designs to suit requirements.

The valves have removable plugs and seats and their linear spline plugs are interchangeable with seats for all valve sizes. Parabolic plugs with removable seats are also included in this range. Flow control in valve travel is governed by the shape of the grooves, milled or ground, in the plug surface ; and the flow rangeability is 50 : 1.



Diaphragm-operated valve for pressures up to 60,000 lb per square inch

The valve seats, screwed into the body, are lapped to ensure a tight shut-off and the seats can be removed by a standard box wrench. Each of these valves, one of which can be seen in the illustration, is flow tested for C_v accuracy before despatch from the makers.

[Reply Card No. E4405]

Industrial Heating Jackets

CLAIMED to be the largest tyre plant in the world, the Rustyfa factory in the Soviet Union will supply tyres of all sizes from earth-moving equipment to motor-cars. This production unit will be supplied by a British consortium.

The various melting tanks, storage containers and special pressure vessels used for the ingredients required in the manufacture of tyres have been engineered by Simon Handling Engineers, Ltd., Cheadle Heath, Stockport, Cheshire. All those vessels that require heating to exact temperatures have been supplied with " Isomantle " electric surface heaters by Isopad, Ltd., Barnet By-Pass, Boreham Wood, Herts. Our illustration (Fig. 1), shows one of these heating jackets which

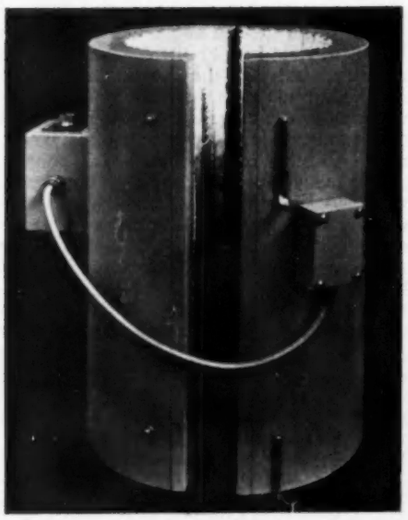


Fig. 1—Heating jacket made in two hinged halves for easy fitting. The bulb of the liquid expansion thermostat is fitted to the heating surface

is made in two hinged halves for easy fitting. The temperature of the heating surface is automatically regulated by thermocouples, their control heads being mounted on a central control panel. In addition, liquid expansion thermostats are fitted to each heating jacket. The sensing bulb is attached to the heating surface as seen in Fig. 1, whilst the control head is fitted to the outer metal casing. These thermostats are so arranged that they give audible warning in case temperatures fall below the required level.

Some of the injection vessels will be used with alternative ingredients and are therefore equipped with two low-temperature alarm units, one calibrated 60 deg. to 100 deg. Cent. and the other 100 deg. to 300 deg. Cent. A number of melting tanks which are being installed have electric surface heaters with a loading of 30kW. They are made in several sections, which again comprise the heating surface, thermal lagging and outer metal casing. Not only the base and sides of the tanks are heated in this manner but the tanks have also been designed with an internal V-shaped section enlarging the heating surface for a given volume and thus preventing any possibility of over-heating the heat-sensitive material.

To keep the interconnecting pipework at the desired temperature, " Isotapes " have been used. These flexible electric heating tapes comprise the heating elements (rendered completely moisture-proof by silicone rubber extrusions) embedded in glasscloth and terminating at one end, which ensures easy and quick installation.

The temperature of these heating tapes is controlled by the same type of thermostat and a batch of these is shown in Fig. 2. The thermostats are fitted to special pipe clamps for mounting on location.

[Reply Card No. E4411]

Miniature Computer Drum

WE have received from IBM United Kingdom, Ltd., 101, Wigmore Street, London, W.1, the accompanying illustration of a miniature magnetic storage drum assembly developed for airborne computers by engineers of the IBM Federal Systems Division laboratory at Owego, New York. Information is recorded on the magnetic surface of a stainless steel drum 3in long and 3in in diameter, which spins at 6000 r.p.m. The drum itself is in the form of a thin shell, this construction being dictated by the need to withstand severe vibrations and shock. The " shell " design concentrates the mass of the drum at the surface where it is most needed, and therefore provides maximum strength and rigidity with minimum weight. It is stated that a stress more than fifteen times the force of gravity can be withstood, and that the drum is so rigid that it is not affected by high frequency vibrations in missiles. The assembly weighs 8 lb as against a weight of 235 lb for conventional drum assemblies.

Drum assembly for airborne computers, showing slider bearings for read/write heads, seven of which are in position

The lightweight frame surrounding the rotating drum holds the slider bearings in which miniature magnetic recording heads are embedded. As the drum spins at 6000 revolutions a minute, it builds up a very thin layer of air over its surface. The slider bearings ride on this film of air, staying only 100 millionths of an inch away from the drum even under severe vibration. In the accompanying illustration all but seven read/write heads have been removed from the assembly to permit a view of the drum surface through the slots.

[Reply Card No. E4412]

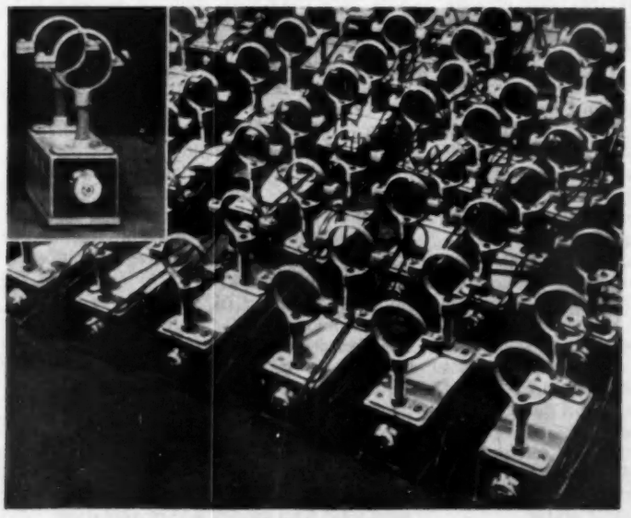


Fig. 2—Thermostats for flexible heating tapes on pipelines. The control knob has a locking device to prevent accidental alteration of the setting

Radio Hobbies Exhibition

IT is announced by the Radio Society of Great Britain that its International Radio Hobbies Exhibition will be held this year at the Royal Horticultural Society's Old Hall, Westminster, from November 23 to 26. It will be open from 11 a.m. to 9 p.m. daily. Sections will be devoted to components for home construction of all types of v.h.f., u.h.f., s.s.b., and transistor transmitters and receivers. Transistor mobile equipment and its components and power supplies will be featured, and home-constructed television transmitting station equipment will be shown. Commercial exhibits will include kits and components for home construction of apparatus ranging from simple radio receivers to transmitters and television equipment. An all-transistor communications receiver will be available for the first time. The R.A.F., Royal Navy and Territorial Army Sections will show the latest services communications equipment and apparatus built by members of their radio clubs. The Society's radio station, GB3RS, will operate daily on c.w., r.t. and s.s.b. transmissions, and will also serve as a means of demonstrating manufacturers' equipment.

Launches and Trial Trips

MOBIL ACME, oil tanker; built by Alexander Stephen and Sons, Ltd., for Mobil Tankships, Ltd.; length between perpendiculars 525ft, breadth moulded 74ft, depth moulded 39ft, deadweight 19,000 tons on 30ft 9in summer draught, 18,300 tons on 30ft service draught, service speed 15½ knots; twenty-seven cargo oil tanks, one cargo pump room, four horizontal, turbine-driven, 2000 gallons per minute cargo pumps; one set of two-cylinder, cross compound, double-reduction geared turbines, 9250 s.h.p. at 108 propeller r.p.m., steam supplied at 600 lb per square inch and 850 deg. Fah. by two Foster Wheeler E.S.D. boilers. Trial, July 2.

EGNATIA, car ferry; built by Chantiers Reunis Loire-Normandie for Hellenic Mediterranean Lines; length between perpendiculars 357ft 8in, breadth moulded 56ft 4in, depth to bulkhead deck 21ft 2in, draught loaded 13ft 6in, deadweight 600 tons; passengers 762 (day), 638 (night), 115 cars, Denny-Brown stabilisers; two Sulzer diesel engines, 6300 h.p., loaded service speed 17·8 knots. Trial, July 11.

STONEGATE, oil tanker; built by Smith's Dock Company, Ltd., for the Turnbull Scott Shipping Company, Ltd.; length between perpendiculars 530ft, breadth moulded 69ft 3in, depth moulded 39ft, deadweight 18,000 tons in 29ft 10in draught, service speed 14½ knots; thirty-three cargo oil tanks, one cargo pump room, four 400 tons per hour turbine-driven cargo pumps and two stripping pumps; two 400kW, 440V, 60 c/s, diesel-driven alternators, one 100kW steam-driven alternators, two Babcock and Wilcox watertube boilers; Hawthorn-Doxford oil engine. Launch, July 11.

BARNSLEY, trawler; built by the Goole Shipbuilding and Repairing Company, Ltd., for Consolidated Fisheries, Ltd.; length between perpendiculars 137ft 3in, breadth 28ft, depth 14ft 3in, Mirrlees KSSDM8 diesel engine, 1120 b.h.p. at 270 r.p.m. Launch, August 9.

INDUSTRIAL NEWS

Engineering Production

Production in the engineering and electrical goods industries in June, which this year included the Whitsun holiday, has been estimated as 6 per cent higher than a year earlier, according to the latest statistics published by the Board of Trade. Taking May and June together, the increase was 8 per cent, whilst in the first four months of this year, production was 13 per cent more than in the corresponding four months of last year. Since engineering output was expanding rapidly in the first half of last year, these latest statistics do not indicate a fall in production, the Board of Trade points out, but a marked slackening in the rate of growth. This may be attributed mainly, the Board suggests, to the production of consumer goods, which turned downwards in the first quarter and lost further ground in the second.

The volume of exports of the products of the engineering and electrical goods industries in the second quarter was a little less than in the first quarter, when engineering exports were particularly high, but 5 per cent more than a year earlier. In the first half of 1960 the volume of engineering exports was 9 per cent higher than in the first half of 1959.

New orders for engineering and electrical goods, which had been heavy in the first four months of this year, slackened in May and June, the Board says, although the inflow was still substantial and continued to exceed deliveries. In these two months orders on hand increased by 3 per cent, the largest part of the increase being for the home market.

Sandwich Courses

Colleges of advanced technology and technical colleges in England and Wales are offering over 330 sandwich courses in the session beginning this month, compared with just under 300 last year and about 100 five years ago. A booklet listing the latest information available concerning sandwich courses and block release courses in further education establishments in England and Wales has now been published by the Ministry of Education. It is expected, the Ministry says, that more than 10,000 students will enrol this month for sandwich courses, compared with just over 2000 five years ago. The subjects covered by the courses include civil, mechanical and electrical engineering, electronic engineering, rubber technology and business studies.

Most of the new sandwich courses are pitched at a level corresponding to that of a university degree, the Ministry states. Nearly 100 of them are aimed at a degree or a diploma in technology, which is equivalent in standard to an honours degree, and of these, over fifty are offered by the colleges of advanced technology. At a slightly lower level, over 100 courses lead to the higher national diploma, which corresponds roughly, the Ministry says, to a pass degree. A number of other courses lead to diplomas which give exemption from the examination requirements of various professional bodies.

A separate section of the booklet gives details of more than forty block release courses. Education for technicians and craftsmen has hitherto taken the form almost exclusively of one day's release per week, but now, the Ministry of Education says, many colleges are experimenting with block release courses which give the students more time in college and a chance to broaden their studies.

Construction Work Overseas

The Board of Trade has announced, in a survey published in its journal for September 2, that in the twelve months ended March, 1960, British contractors carried out construction work overseas to the value of nearly £124 million. This shows an increase of more than £3,500,000 over the previous twelve months and is the highest figure recorded since the Ministry of Works' surveys began in 1955. The figures for 1959-60 include the work of sixty-seven firms, few more than in the previous year, and the work has been carried out in nearly seventy different countries.

In the five years since 1954-55, when the total was £70,000,000, the value of work carried out overseas has risen by nearly 80 per cent. Figures for the amount of foreign currency brought to the country are not yet available, but the Board of Trade suggests that it is probably fair to assume that the amount earned by these overseas activities has increased at least in parallel with the increase of the value of the work.

Few individual export items, the Board states, have increased by more than the 80 per cent shown by the contractors' figures. The value of total exports and re-exports has risen during the same period by only 20 per cent and the value of manufactured goods exported by nearly 30 per cent.

Unemployment

The Ministry of Labour's final unemployment figures for Great Britain at August 15 show that 321,357 people were registered as unemployed, of whom 313,394 were wholly unemployed and 7963 were temporarily stopped. The number of people unemployed for more than eight weeks was 159,587, which was 51 per cent of the wholly unemployed. Unemployment figures at July 11, showed that 291,951 people were unemployed, of whom 281,707 were wholly unemployed and 10,244 were temporarily stopped.

The main changes in unemployment between July 11 and August 15, the Ministry points out, were reductions of 2400 in shipbuilding and marine engineering and 2200 in timber, furniture, &c., and increases of 1200 in both engineering and electrical goods and in miscellaneous services. Unemployment in manufacturing industries as a whole, the Ministry says, fell by 2600. The number of boys and girls not previously in employment who were registered as unemployed increased by 26,853 to 32,108.

The principal changes in the number of unfilled vacancies between July 7 and August 10 were increases of 2000 in coal-mining and 1400 in construction ; and decreases of 8200 in miscellaneous services, 6000 in the distributive trades and 3500 in engineering and electrical goods. Unfilled vacancies in manufacturing industries as a whole fell by 9000, the Ministry of Labour states.

Trades Union Congress

In his presidential address to the ninety-second annual Trades Union Congress on Monday of this week Mr. Claude Bartlett paid tribute to the " unknown servants " of trade unionism, and enjoined those who were hostile in their criticism of the movement to remember the uncounted, unpaid and unacknowledged hours of service given by them, not only to their unions and to industry, but to the community. The 8,000,000 trade unionists, Mr. Bartlett said, were not worse citizens than the rest of the community, indeed, they were often better, for in no other organisation in this country did so many people get and take the opportunity to learn by self-instruction the principles and processes of democracy. Occasionally, he added, it was true that the proper procedures and responsibilities were overlooked in the heat of an industrial argument. Impatience got the upper hand of wisdom and the promises made in agreements were broken. Members taking action of that sort, Mr. Bartlett warned, risked doing harm not only to their own union but to the trade union movement as a whole. But what was much worse, though more rare, Mr. Bartlett continued, was the emergence—in some places sporadic, in others semi-permanent—of an organised conspiracy to defy union rules that had been democratically decided upon and ignore the agreements that had been properly negotiated for settling grievances and avoiding disputes. The sensible trade unionist, Mr. Bartlett said, did not want to have two spokesmen, each in conflict with the other. He did not need a union within a union. He did not relish being " flung out of work " and his earnings cut because a dozen men in another workshop had downed tools before getting down in an orderly way to the settlement of a dispute that had angered them. The loyal trade unionist, Mr. Bartlett stressed, saw the strike weapon as an indispensable part of the trade union armoury, but its value depended not on how often it was used, but on how wisely it was used.

Speaking of the need to equip unions with the knowledge they needed to cope confidently with the variety of questions that came their way, Mr. Bartlett warned that they must not be left to be baffled by the jargon of the specialists in production and management techniques who were now found in increasing numbers in industry and in commerce. As management drew increasingly on the services of specialists, so too the unions would, he believed, wish to buttress their practical experience by adding to the number and range of the specialists at work in their service.

In his references to unemployment, the President said that national averages obscured a lot of local hardships. Too many men, he said, had been out of work for far too long in too many towns. It made better social and better economic sense, Mr. Bartlett thought, to graft new industry within the areas where jobs were scarce than to transplant people to congested towns where homes were scarce and rents were high. He urged the trade union movement to do its utmost to see that the new powers made possible by the Local Employment Act were used with energy and imagination.

PERSONAL AND BUSINESS

Appointments

MR. B. F. AKERMAN has been appointed general manager of Charles Carr, Ltd.

MULLARD EQUIPMENT, Ltd., announces that Mr. F. S. Barton, M.I.E.E., has been appointed to the board of directors.

UNION CARBIDE, Ltd., has announced the appointment of Mr. W. B. Whitworth as sales manager of the alloys division.

MR. P. P. FOWLER, A.M.I.C.E., has been appointed civil engineer (transmission) of the Central Electricity Generating Board.

SIR W. H. BAILEY AND CO., Ltd., announces the appointment of Commander E. G. Sutton, M.I.Mech.E., as works director.

MR. H. R. SCHOFIELD, Assoc.I.E.E., has been appointed chief transmission project engineer to the Central Electricity Generating Board.

MR. J. D. MAITLAND has been appointed assistant secretary of English Electric Aviation, Ltd. The company is a subsidiary of British Aircraft Corporation.

i. I. CASE CO., Ltd., announces the appointment of Mr. Edward T. Green as industrial sales manager. His appointment will cover the British market.

RICHARD SUTCLIFFE, Ltd., has announced the appointment of Mr. Malcolm Brocklesby as district technical manager for the West Midlands Division of the National Coal Board.

FOSTER WHEELER, Ltd., has announced that Mr. C. E. H. Verity, its managing director, has been elected a director of the parent company, Foster Wheeler Corporation of New York.

MR. A. R. O. WILLIAMS has been elected president of the Institution of Mining and Metallurgy for 1961-62. He will take office in May, 1961, in succession to Professor David Williams.

FOSTER WHEELER, Ltd., announces the following appointments to the board of directors: Mr. R. L. J. Hayden, Mr. C. J. Geiss, Mr. J. F. G. Arman, Mr. A. S. Bridgwater and Mr. J. McLean.

THE MERSEY DOCKS AND HARBOUR BOARD has appointed Mr. N. A. Matheson to be its engineer-in-chief, in succession to Mr. J. D. J. Saner who is retiring from the Board's service at the end of the year.

MR. G. R. FRANCIS has been appointed traction engineer to British United Traction, Ltd. He will be responsible for initiating and progressing all new traction installations for both shunting locomotives and railcars.

MR. A. R. JACKSON has been appointed to the board of directors of the Consolidated Pneumatic Tool Company, Ltd. Mr. Jackson is general manager of the company's Australian branch and will continue in charge of operations in that country.

RICHARD HILL, Ltd., a member of the Firth Cleveland Group of Companies, states that Mr. A. W. Thwaites, commercial manager, has been appointed commercial director, and Mr. H. M. Macgregor, works manager, has been appointed works director.

SMITHS INDUSTRIAL DIVISION has announced the retirement of Mr. Alfred J. Mann after forty-one years' service with David Harcourt, Ltd. He was appointed general manager in 1949. Mr. A. W. Daymond-King will now be responsible for production at Linkula Works.

EXPANDITE, Ltd., announces that Mr. J. H. Price has been appointed general manager of its Australian company, Expandite (Australia) Pty., Ltd. He will take over from Mr. J. M. Robb who will be returning to the parent company in November to take up a position in the overseas development division.

MR. D. G. HEMMANT has tendered his resignation and will not return to Powell Duffryn Technical Services, Ltd., at the conclusion of his secondment to the British Mining Equipment Export Association. Mr. R. Turner, who has acted as managing director during Mr. Hemmant's absence, has been appointed the sole managing director of the company.

MOBIL OIL COMPANY, Ltd., has announced that Mr. J. Blake Middleton, who will retire early next year on achieving forty-years' service with the international group of Mobil Companies, resigned his directorship of Mobil Oil Company, Ltd., on August 31. To fill the resulting vacancy, Mr. B. R. Fraser has been elected a director and will be in charge of manufacturing.

Business Announcements

REDWOOD CITY ENGINEERING, Ltd., Arkwright Road, Reading, Berks, has changed its name to Ampex Great Britain, Ltd.

A. P. NEWALL AND CO., Ltd., has moved its London office to 19-20, Grosvenor Street, W.1. (telephone, Hyde Park 3342).

P. AND B. PLASTICS, Ltd., has moved into larger premises at Waterloo Works, Gorsey Mount Street, Stockport, Cheshire (telephone, Stockport 4007-8).

PYROTENAX, Ltd., has opened a new sales office at 69, Loughborough Road, West Bridgford, Nottingham (telephone, Nottingham 83805). Mr. J. Wallen will be in charge of the new office.

REDIFON, Ltd., London, S.W.18, a company in the Rediffusion Group, has announced the establishment of Redifon Electronic Inc., at 5265, Watson Street, N.W., Washington, D.C., U.S.A. (telephone, Kellogg 7-1558).

THE BENJAMIN ELECTRIC, Ltd., Tottenham, London, N.17, states that due to trade mark registration difficulty, it is changing the name of its new range of commercial fluorescent fittings, having the mini-cell louvre construction, from "Flo-line" to "Sky-line."

SIVYER STEEL CASTING COMPANY, of Milwaukee, Wisconsin, U.S.A., and A.P.V.-PARAMOUNT, Ltd., of Crawley, Sussex, have concluded a licensing arrangement whereby A.P.V.-Paramount, Ltd., is to manufacture and sell Sivyer refinery fittings in Europe and in the British Commonwealth.

J. C. BAMFORD (EXCAVATORS), Ltd., Lakeside, Rocester, Staffs, announces the formation of a new company, J. C. Bamford (Exports) S.A., 2, Avenue de la Rasude, Lausanne, Vaud, Switzerland. It will control all export sales, carry spares and provide service for J.C.B. equipment on the Continent.

DARLINGTON CHEMICALS, Ltd., states that the name of one of its principal subsidiary companies, the British Refrasil Company Ltd., Stillington, Co. Durham, has been changed to Darchem Engineering, Ltd. The division of the company supplying "Refrasil" insulation blankets will be known as the British Refrasil division.

VICKERS-ARMSTRONGS (ENGINEERS), Ltd., and RACINE HYDRAULICS AND MACHINERY INCORPORATED, of Racine, Wisconsin, U.S.A., announce that they have reached agreement whereby the two companies jointly develop their hydraulic interests and manufacture and sell each others hydraulic products on a world-wide basis.

THE PYRENE COMPANY, Ltd., 9, Grosvenor Gardens, London, S.W.1., announces that it has acquired the business of S. F. Roberts, Ltd. The company, which has been renamed S. F. Roberts (1960), Ltd., becomes one of the Pyrene Group and manufacture of its safety products will be carried out at the Windmill Road Works, Brentford.

YALE AND TOWNE INTERNATIONAL INC. has completed arrangements to establish a branch office at Zug, near Zurich, Switzerland. Mr. Charles F. Burgman has been appointed managing director of Yale and Towne International Inc., and Mr. John O. Sewell, managing director of the British divisions of Yale and Towne Manufacturing Company, has been appointed a director and vice-president.

G. AND J. WEIR, Ltd., Glasgow, Scotland, was licensed last year by Clark Brothers, Company, Division of Dresser A. G., to build the Clark design of centrifugal and reciprocating compressors. The firm has now been assigned to manufacture Clark "Isotemp" packaged centrifugal air compressors in seven frame sizes with capacities ranging from 5000 to more than 50,000 cubic feet per minute.

Contracts

IWEL ENGINEERING, Ltd., 7-11, Old Bailey, London, E.C.4, has been awarded an £8500 contract for the supply and erection of equipment for a new abattoir for the Town Council of Forfar, Angus.

ASHMORE, BENSON, PEASE AND CO., Ltd., Stockton-on-Tees (of the Davy-Ashmore Group), has received an order for a 26ft hearth blast-furnace for the Ravenscraig works of Colvilles, Ltd. Another member of the Davy-Ashmore Group, Davy and United Engineering Company, Ltd., Sheffield and Glasgow, is to build the new 68in semi-continuous hot strip mill for Ravenscraig, together with a 68in, four-stand tandem cold strip mill and a 68in single-stand temper mill for Colvilles' Gartcosh works.

DISTINGTON ENGINEERING COMPANY, Ltd., Workington, a branch of the United Steel Companies, Ltd., is to build a single-strand vertical continuous casting plant for large slabs for the Panteg works of Richard Tomas and Baldwins, Ltd. The plant, which will be build under licence from Concast A.G., Zurich, will cast steel of various grades, including stainless, up to 60in by 6in.

DISTINGTON ENGINEERING COMPANY, Ltd., is also to build a vertical continuous casting plant, in conjunction with Concast A. G., Zurich, on behalf of Canara Workshops, Ltd., Mangalore, India. It will be a single strand unit for casting billets from 2in to 4in square, but will be equipped initially for 3½in square billets. Provision is being made for a second strand to be added later.

SIR JOHN JACKSON, Ltd., of London, has been awarded a £758,755 contract for the construction of the southern approach road to the Dartford-Purfleet tunnel. The approach road starts at a two-level junction with Princes Road, Dartford (A.2) with underpasses and slip roads to eliminate cross traffic. From this junction, the road will curve northward to the tunnel entrance. It will pass under Watling Street (A.296) and London Road (A.226) and over the North Kent lines of British Railways. The northern approaches to the tunnel are well advanced. The two halves of the tunnel excavations, from shafts sunk in the river banks, met last year, and the outward drives from the shafts to the portals have been completed.

HOLLAND & HANNEN AND CUBITTS (GREAT BRITAIN), Ltd., has been awarded a contract to build a new head office and printing works for the *Cambridge Daily News*. The £170,000 contract is due for completion in October next year. Designed by L. A. Culliford and Partners, the office block at 51, Newmarket Road, Cambridge, consists of ground, first and second floors. The adjoining printing works will have a basement, ground and first floor. The printing works is designed to accommodate an eight unit printing press founded in the basement and rising to first floor level. At first, three units will be installed, with a gradual build-up to eight units. There will also be a small type foundry. The building will have a reinforced concrete frame. A garage and workshop forming an "L" at one end of the building will be steel-framed. Overall length of the building will be 242ft with a width of 88ft, and the offices will rise to a height of 35ft above ground level.

ASSOCIATED ELECTRICAL INDUSTRIES, Ltd., Telecommunications Division, Transmission Department, has received a £130,000 order for carrier transmission equipment from Murphy Radio of Welwyn Garden City. The equipment will form part of a radio network for the 720-mile Oil India pipeline project in Northern India. The main purpose of the radio link will be to provide the control headquarters of Oil India Private, Ltd., at Nunmati, with telemetering facilities for monitoring oil flow along the pipeline from the issuing station at Nahorkatiya, in Northern Assam, to the terminal refinery at Barauni, in Bihar. The link will have an ultimate capacity of thirty-four channels for telemetering and teleprinter facilities and speech transmission, and two channels will be allotted to control purposes. Transistorised channelling equipment will be installed at the terminal and intermediate stations, and at most of the repeater stations along the route. Access points at the repeater pumping stations and maintenance stations will allow mobile v.h.f. links to be fed into the main network.

STANDARD TELEPHONES AND CABLES, Ltd., has received contracts to the value of approximately £1.8 million from Cable and Wireless, Ltd., for the supply of a complete multi-circuit telephone cable system between the United States and Bermuda, to be owned jointly by Cable and Wireless, Ltd., and the American Telephone and Telegraph Company. This is believed to be the first time that a complete submarine telephone cable system terminating in the United States will be wholly manufactured elsewhere. Terminal equipment, 750 nautical miles of submarine coaxial cable, thirty-four submerged repeaters and three submerged equalisers constitute the bulk of the contract; the system is due for completion late next year. The frequency bandwidth on the cable will allow eighty two-way simultaneous telephone calls, using new channel equipment. The cable will terminate at Manahawkin, New Jersey, and Flatts, Bermuda, linking the U.S. trunk network and the Bermuda local network. The rigid two-way repeaters, for amplifying in both directions of transmission along the single cable, will be of a similar type to those being supplied by the company for the U.K.-Sweden and U.K.-Canada (Cantat) cables.

CONTINENTAL AFFAIRS

by Our Continental Editor

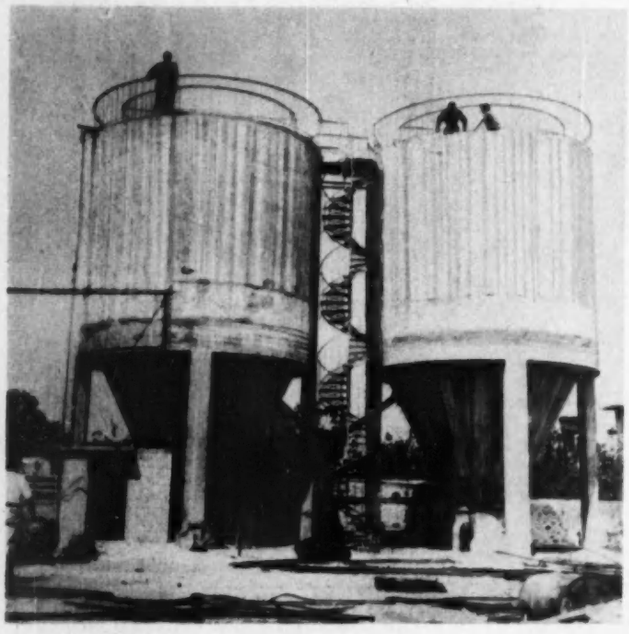
Tannery Effluent Purification

WASTE waters from tanneries, a notoriously evil-smelling kind of effluent, contain, in addition to germs and dirt, large quantities of albumen from the animals' blood, gelatine from the skin, and proteins and other substances. A recent case occurred in Athens, where the Hygiene Department required a tannery, whose works had been brought within the Department's jurisdiction by the expansion of the city, to purify its effluents before discharging them into the municipal sewers.

Filtration having proved unsuccessful, chemical purification assisted by mechanical agitation was tried but had to be abandoned because oxidation was not complete; corrosion of the machinery resulted in heavy maintenance costs, and a great amount of power was needed to drive the plant.

On the advice and with the co-operation of Atlas Copco Greece, the following method was introduced, which has proved successful. The effluent is pumped alternately into one of two concrete tanks. These tanks, which are shown in the accompanying illustration, stand 30ft high and each has a capacity of 5250 cubic feet. Compressed air is supplied to orifices in the bottom of the conical ends, formed by drilling an 800mm diameter hoop of ¾in copper pipes with eight equally spaced holes of 4mm diameter. The hoops are connected by 1in mains to an Atlas Copco "KE GRAS" air compressor (a 7·5 h.p. twin-cylinder machine with a delivery of 30 cubic feet of free air per minute at up to 100 lb per square inch).

The tannery effluent in the tanks is mixed with chloride of lime and chromate salts. This mixture is agitated by means of compressed air for six hours and then left to settle until the cone of the tank is filled with precipitate and the water above is odourless and pure, a process which takes between one and two hours. The compressed air not only agitates the mixture but provides oxygen for complete oxidation. After settlement the purified effluent is piped off to the sewer and the precipitate stored in an underground tank from which it is periodically removed for dumping outside the city.



Two 30ft high concrete tanks, each with a capacity of 5250 cubic feet, in which the tannery effluent is purified. The compressor house is at base of tank on left

Agard Meetings

The AGARD Avionics Panel is to present a Symposium on "Radio Navigation" in conjunction with the Tenth AGARD General Assembly in Istanbul, Turkey. The panel will convene for six days, from October 3 to 9, at the University of Istanbul. Two days during the week will be set aside for attendance at the formal functions of the General Assembly. Approximately thirty-five technical papers will be presented and discussed. These will cover general problems concerned with navigation, including papers on wave propagation, as well as radio navigation including Doppler and air traffic control. One day will be devoted to space- and astro-navigation, and one to display methods and automatic approach and landing. Scientists from industry and governmental agencies will participate. The Federal Aviation Agency (U.S.), National Bureau of Standards (U.S.), Ministry of Aviation (U.K.), Royal Radar Establishment (U.K.), and Ministry of National Defence (France) will be represented. Although the meeting is unclassified from a security viewpoint, attendance is limited to those who are authorised to attend by either the AGARD National Delegates, or by members of the AGARD Avionics Panel.

The Aero Space Medical Panel of AGARD will hold its sixteenth meeting in Istanbul, from October 3 to 8. Technical papers in clinical aviation and space medicine will be presented. The purpose will be to provide scientific information on the present state of aviation medicine, and to discuss progress in modern methods and medical problems of mutual interest within the N.A.T.O. community.

The programme will include discussion of aviation medicine consultation problem cases, the role of elective surgery in a modern air force, vision problems in high and low altitude flight, the effects of acceleration on respiration and circulation, animals and man in space, and comments on the future astronaut selection programme.

Turbodrilling of Exploratory Bore-Holes

Exploratory bore-holes were recently drilled on the site of the Meffrouch dam in Algeria with a "Neyrfor" turbodrill, made by Ets. Neyrpic, Grenoble. This, it is stated, is the first time that a "Neyrfor" turbodrill has been used for such work. The job was completed successfully without any other special equipment having to be used.

Meffrouch dam will supply the Oran and Tlemcen regions with drinking water and may also be used to drive an impulse turbine. A multiple arch dam, consisting of prefabricated units, will be 25m high and its buttresses will be set at 25m centres. In order to investigate the nature of the underlying rocks, it was necessary to excavate two 1·5m diameter, 30m deep shafts in a dolomite formation where pneumatic drills were of little use.

To avoid this difficulty it was planned to drill seven approximately 312mm diameter holes for each shaft, one at the centre and six on the circumference. This was to be done with conventional rotary drilling equipment. Pneumatic drills would then be used to remove the remaining rock. However, this method had to be abandoned after the first attempt since too much time had to be spent in moving the rig around the circumference of the shaft.

The contractor, Travaux Souterrains S.A., then decided to use a "Neyrfor" 7¼in o.d. turbodrill in conjunction with a drilling rig owned by Forasol S.A. This made it possible to drill all seven holes for one shaft without having to move the drilling rig.

The turbodrill was fitted with specially designed "S.M.F." three-cutter bits, the weight on the bit being approximately 5 tons, and the circulation rate 2350 litres per minute. The holes for the two 30m deep shafts were drilled at a penetration rate of approximately 10m per hour.

The turbodrill was then used successfully to drill five 1·5m diameter by 10m deep dam inspection shafts, an ordinary crane being used for this work instead of a drilling rig. Drilling tongs were employed to prevent the turbodrill casing from rotating.

International Film Festival

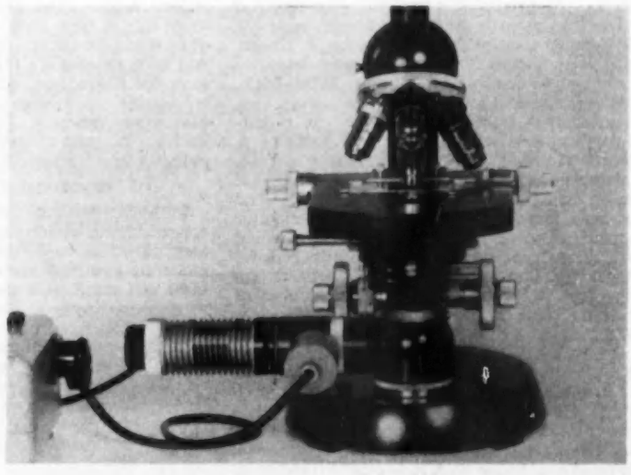
One hundred and sixty films from over twenty different countries will be presented during the First International Festival of Industrial Films which will be held at Rouen from October 4 to 8. Those interested are asked to write to the Permanent Secretariat, International Festival of Industrial Films, C.O.M.E.T., Quai de Paris, Rouen (Seine-Maritime), France. The subjects covered by the films selected for presentation will cover information and training, accident prevention, human relations, research, productivity, time and motion study, advertising, marketing research, general information and prestige films.

International Conference on Gearing

The Verein Deutscher Ingenieure, VDI/AWF-Fachgruppe Getriebetechnik (Gear Technology Section of the VDI/AWF), and the Fachgemeinschaft Getriebe und Antriebselemente of the Verein Deutscher Maschinenbau-Anstalten (Gearing and Transmission Section of VDMA) will hold an International Conference on October 18 and 19 at Essen. German and foreign specialists will deal with the following principal themes: Novikov and other special high-duty gears; development tendencies in gear manufacture; manufacturing accuracy and noise; design of large gear trains; precision gear trains in instrument technology. The papers received in connection with each of these topics will be published at the beginning of the conference and will form the subject of discussions. Full information and the complete programme can be obtained from the Secretariat, VDI-AWF-Fachgruppe Getriebetechnik, Düsseldorf, Prinz-Georg-Strasse 77/79 (telephone 443351, extension 261).

Platform Crane for Lorries

We have received details of a hydraulically-operated crane for mounting on the platform of lorries of 3·5 tonnes capacity, which is made by Steinbock G.m.b.H., Moosburg Oberbayern. The equipment, which weighs 600 kg, is shown in the accompanying illustration. It has a lifting capacity of 900 kg at 3·7m radius, and of 2000 kg at 1·7m radius. The boom can be extended and derricked hydraulically, controls being operated from either side.



(Above) Hydraulic crane for mounting on the back of lorries of 3·5 tonnes carrying capacity or more

(Right) Micro flash unit attached to microscope in place of illuminating mirror

Iron Gate Project

A joint Rumanian–Yugoslav technical and economic memorandum has been submitted to the governments of the two countries concerning the hydro-electric exploitation of the Sip Gorge (Sipska Klisura) near Tekija, known as the "Iron Gate." This important gorge in the lower course of the River Danube could provide the site for a power station producing 8300GWh per annum. At the same time great advantages would accrue to navigation. The memorandum has been prepared by the Belgrade firm "Energoprojekt" and the Bucharest "Institute for Power and Project Study." In its first stage the Sip–Masusi Boba (or Sip–Gura Vall, as it is known in Rumania) power station would cost 278 million dollars which it is hoped may be raised among countries interested in navigational improvements on the Danube. A further 175 million dollars would be required for the second stage power station of Radujevac–Gruja.

Three variants have been studied of which the first envisages a power station in the Sip–Masusi–Boba section, with head-waters at 63m to 67m sea level, and a power station at Gruja, near Radujevac, with head-waters at 38m to 40m sea level. A second is the possibility of a power station near Orsava with impounded level at 63m to 67m sea level, combined with a second station at Gruja with head-waters at 46m to 48m sea level.

The third variant projects three hydro-electric stations, the first upstream of the mouth of Porecka Reka River, near Juce, with impounded level at 63m to 67m sea level; the second at Sip–Masusi Boba with head-waters at 49m to 51m sea level; and the third at Gruja, with head-race at 38m to 40m sea level.

Of these three possibilities, it was the first which was most favourably considered by the Yugoslav–Rumanian Commission. The reasons were that this was the cheapest project with at the same time the greatest general economic effect, and the highest electric yield of which a major proportion could be realised already through the completion of the first stage.

At Sip, the power to be installed amounts to 1450MW, while another 364MW would be installed at Gruja. Output per annum from the two stations would be 8337GWh and 1790GWh, respectively. The cost per kilowatt installed (at a rate of exchange of 632 dinar) amounts to 213 dollars at Sip and 553 dollars at Gruja, or 281 dollars for both schemes combined. This may be compared with 284 dollars per kilowatt of the Tennessee Valley Authority for a total installed power of 966MW.

With regard to navigation, the construction of the dam at Sip would by itself overcome all dangers to shipping which now exist. It would, however, involve the flooding of the town of Orsava in Rumania (population about 8000), and of Tekija and parts of Donji Milanovac (population about 50,000) on the Yugoslav side. Greater depth of water would do away with the present limitations on draught, towing convoys could be formed freely, overtaking and navigation at night would be facilitated, the need to carry pilots would be removed, and during periods of low water shipping could carry on for longer than it can now. The net result, therefore, would be to increase the carrying capacity of the Danube in both directions from 10,000,000 to 24,000,000 tonnes annually.

Output of electric power from the new station would be shared equally by Rumania and Yugoslavia. This is of particular interest to Rumania where hydro-electric resources are limited. The growth of demand for electricity is very great in the two countries, consumption doubling every fifth or sixth year.

New Citroën Plant

Following a decision taken in 1958 to move part of its activities out of Paris, the Citroën company is erecting a new plant near Rennes in Brittany. The choice of the particular district was partly due to the fact that the company has been operating a small factory at the nearby centre of La Barre-Thomas, where 1200 workers are employed. Situated on 160 hectares at La Janais, in open country 7 km south-west of Rennes on the road to Nantes, the new factory will comprise initially four main buildings of which the steelwork has now been completed after seven months erection work, and will soon be under roof.

The new buildings will comprise a press shop, trimming shop, assembly and polishing shop, and painting shop. In addition, separate buildings house the electric generating plant, maintenance department, and stores for inflammable materials. In a central situation will be a community centre. These buildings represent a floor space of 160,000 square metres out of 500,000 square metres for the completed project.

Foundation work involved 500,000 cubic metres of earth movements, the construction of 1·86 miles of roads and of 6·2 miles of drainage culverts and sewers. A pond of 0·5 hectares area was excavated to collect rainwater for use in fighting fires. Over 7 miles of piles were set. Foundations for the heavy presses, which had to withstand loads of up to 2000 tonnes, proved to be a special problem, requiring excavation to bedrock some 30m below the surface. The supports of the presses are independent of the remainder of the structure.

Production in the press shop is scheduled to start later this year, and the rest of the plant is expected to be in operation early in 1962, when about 5000 people will be employed.

Micro Flash Unit

For photo-micrography not only of moving objects but also of permanent slide cultures, Carl Zeiss, Oberkochen (agent: Degenhardt and Co., Ltd., 6, Cavendish Square, London, W.1), has developed the micro flash unit shown in the accompanying illustration. The illumination system for visual observations is arranged in one optical axis directly behind the flash tube. The dimensions of the appropriate special flash tube correspond to those of commercially available low-voltage bulbs. A quite limited expenditure of electric power is sufficient to attain a high luminous density. As compared with earlier versions, the unit is kept smaller and handier at the same time. Moreover, the smaller condensers are charged more rapidly so that the minimum flash interval is reduced to three seconds. Since the required energy does not exceed 30 or 60 watt-seconds the load on the flash tube is very small indeed. A three-lens collector ensures a high illuminating aperture and permits the arrangement of the flash tube in the entrance pupil according to the principle established by Köhler. The light emitted by the apparatus is stated to correspond to the daylight spectrum and to be therefore specially suitable for colour photography. Although designed for use with Zeiss microscopes, the unit can be used with practically any type of microscope as long as it is furnished with an illuminating mirror or permits the attachment of one.

THE AMERICAN SCENE

by Our American Editor

Alternating Gradient Synchrotron at Brookhaven National Laboratory

No. I

The most powerful particle accelerator in the world started operation in July at the Brookhaven National Laboratory, Upton, New York, and accelerated a beam of protons to an energy of over 30,000 MeV. The machine is known as the Alternating Gradient Synchrotron (A.G.S.) and employs a new principle of focusing strong magnetic fields discovered at Brookhaven. The heart of the accelerator is an underground circular magnet 843ft in diameter comprising some 4000 tons of iron and 400 tons of copper.

THE Alternating Gradient Synchrotron (A.G.S.) recently went into operation at the Brookhaven National Laboratory, at Upton, Long Island, New York, producing a beam of protons at an energy of more than 30,000 MeV. This is believed to be the highest energy ever attained by a particle accelerator. It is particularly appropriate that the new machine is situated at Brookhaven, for it was there, in 1952, that the principle of strong focusing of particle beams was discovered. If this discovery had not been made, the magnet for an accelerator capable of reaching the desired energy would have been prohibitively large and expensive. The completion of the A.G.S. represents an important step forward in American studies of nuclear forces and the properties of sub-nuclear particles. It will enable scientists in the United States to study nuclear interactions at energies about five times greater than ever before possible in that country. Another accelerator, quite similar in design and size to the A.G.S., has been completed at the European Organisation for Nuclear Research (CERN) Laboratory, near Geneva. The CERN Proton Synchrotron first produced a proton beam of 24,000 MeV on November 24, 1959, and has since been run at 28,000 MeV. (THE ENGINEER, February 12 and 19, 1960).

Since 1954, the most powerful accelerator in the United States has been the 6200 MeV Bevatron at the University of California's Lawrence Radiation Laboratory. With a machine in the 30,000 MeV range, the physicists at Brookhaven expect to learn more about the many kinds of particles, such as mesons and hyperons, and the various " anti-particles " that are produced in target nuclei by bombarding them with high energy protons. Construction of the A.G.S., which includes 240 magnets placed in a ring-shaped 18ft square tunnel ½-mile in circumference, was started in late 1955, following several years of preliminary design work. The total cost of this research facility, including a 60,000 square foot service and laboratory building and an 85,000 square foot experimental building, is approximately 13,000,000 dollars.

The Brookhaven National Laboratory was created after World War II, on the site of the U.S. Army Camp Upton, by Associated Universities, Incorporated, an organisation established by Columbia, Cornell, Harvard, John Hopkins, Massachusetts Institute of Technology, Pennsylvania, Princeton, Rochester, and Yale Universities for the pursuit of large research projects. Brookhaven National Laboratory is operated by Associated Universities, Incorporated, for the U.S. Atomic Energy Commission for research in physics, chemistry, biology, medicine, and related fields. The Laboratory lies about 70 miles east of New York City, just over half-way out toward the eastern tip of Long Island. Here was built the world's first large particle accelerator, the Cosmotron, completed in 1952, which is capable of producing 3000 MeV protons. Cosmotron research has already contributed greatly to man's knowledge of elementary particles and high-energy physics.

HISTORICAL BACKGROUND

In 1929, the late Dr. Ernest O. Lawrence conceived the cyclotron. A cyclotron accelerates particles many times in succession with moderate electrical voltages, thus achieving the same end result as a single acceleration with a very high voltage. This is the fundamental principle involved in all circular magnet accelerators. In the cyclotron, the magnetic field guides particles in circular paths inside the vacuum chamber. A radio-frequency electrical device, synchronised with the particle rotation, boosts the energy of the particles on each revolution. As they gain energy, the particles spiral out from the centre of the chamber to its periphery, where they strike a target, or emerge from a slit. A cyclotron is suitable only for " heavy " particles such as protons or other atomic nuclei. The cyclotrons began with the Lawrence 4in, 80,000eV instrument, built in 1930. Their size grew successively larger until they began, in the early 'forties, to approach a limit of 20 to 30 MeV imposed by relativistic mass increase of the particles at high energies. The increase of mass decreases the revolution frequency of the particles so that they drop out of synchronism with the accelerating voltage.

In 1945, Professor Edwin M. McMillan at the University of California in Berkeley, and independently Professor V. Veksler in Russia, conceived the theory of phase stability. The phase stability makes it practical to vary the interval between electrical impulses, by frequency modulation, to accommodate the rising energy and mass of the particles. Frequency modulated cyclotrons have now exceeded 700 MeV and could, in principle, be built for even higher energies. However, the cyclotron magnet and auxiliaries become unwieldy in the range of 1000 MeV, since the entire orbit region must be filled with magnetic field.

The betatron, useful only for electrons, was first demonstrated by Professor Donald Kerst in 1942. It uses a ring of magnetic field in a toroidal vacuum chamber and, instead of spiraling the accelerated particles out, performs the acceleration process at nearly constant diameter. As the particles gain energy, they can be kept in a constant orbit by increasing the strength of the magnetic field. Acceleration is done in the betatron by varying the magnetic flux threading the orbit—analogous to the action of a transformer. Technical and economic considerations have limited this device to some 300 MeV.

In the late 'forties, the " synchrotron " was devised by combining the ring-shaped magnet of the betatron with the synchronised radio-

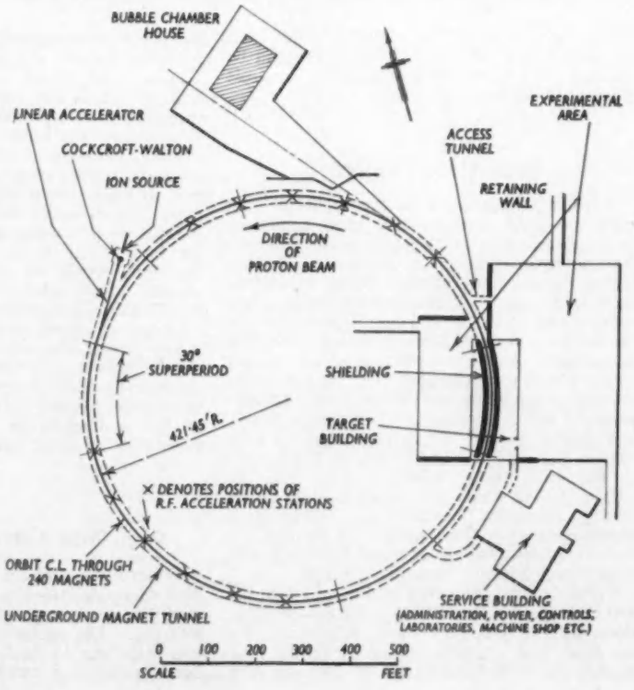


Fig. 1—Plan of Alternating Gradient Synchrotron at the Brookhaven National Laboratory

Fig. 2—Aerial view of the Alternating Gradient Synchrotron with magnet circle, linac building and target building

frequency acceleration of the cyclotron, thus realising both the economy of the former and the higher energy potentialities of the latter. Some synchrotrons accelerate electrons and some protons. The first one to exceed 1000 MeV was the Brookhaven "Cosmotron," a proton synchrotron, which first produced a 1000 MeV beam in 1952 and now runs at 3000 MeV. Next came the 1000 MeV proton synchrotron at Birmingham in 1953. The 6000 MeV "Bevatron" at the University of California was completed in 1954. In 1957, the 10,000 MeV "Synchrophasotron" at the Dubna Laboratory near Moscow, the largest conventional synchrotron now in operation, reached its full energy. This latter machine pointed up a new limitation : even with its ring-shaped form its magnet weighs 36,000 tons. Even with improved design techniques, the size, weight, and cost of the magnet and power machinery for a synchrotron of some 20,000 MeV would be enormous. In the early 'fifties it became evident that a new approach was necessary if particle accelerators of much higher energy than 10,000 MeV were to be built.

Then appeared the principle of "strong focusing" or "alternating-gradient," permitting the use of ring magnets of great diameter but small cross section. Discovered by E. D. Courant, M. S. Livingston and H. S. Snyder at Brookhaven, the idea was published in 1952. The design of the Brookhaven A.G.S. is based on calculations of orbit theory by Dr. Courant. It has since been found that a similar idea of strong focusing had been proposed two years earlier by Nicolas C. Christofilos in Greece, but had not been published. In the conventional synchrotron, the forces necessary to restore a particle to its orbit had been built into the magnet by the introduction of uniform field gradient. Simultaneous focusing in both vertical and radial directions could be achieved only with relatively weak gradients, and hence weak forces. As a consequence, the particles wandered considerable distances from their orbits, and magnetic field had to be provided over a considerable volume. Hence the enormous size of the magnet required for the Russian machine.

Much stronger restoring forces can be introduced by the use of high field gradients, if the gradients are reversed periodically around the ring. In this configuration, the beam is strongly focused in one plane and simultaneously strongly defocused in the other plane. The sequence of focusing and defocusing fields yields a net strong focusing force. This method has reduced the necessary magnet cross section to the point where only 4000 tons of steel are required for the A.G.S., even though its diameter is 843ft.

Alternating gradient machines of various sizes are now under construction in a number of laboratories. Next largest in size to the A.G.S. is the proton synchrotron (P.S.) at the CERN Laboratory near Geneva, which first produced a 24,000 MeV beam in November, 1959, and has since been operated at 28,000 MeV. From the very start, there has been close co-operation between scientists from CERN and Brookhaven, including joint meetings to discuss detailed design problems, and the interchange for short periods of key personnel.

Electron Analogue

Before starting the construction of the A.G.S., the Brookhaven design group decided to build a 10 MeV alternating gradient electron synchrotron, using electrostatic bending and focusing. This machine, rather than representing a model of the larger synchrotron, was a precise analogue computer for obtaining an accurate solution of the equations of motion of charged particles in alternating gradient fields. Moreover, complex variations could be inserted and their effects studied. In December, 1955, an electron beam in the analogue was accelerated to 5 MeV. Design calculations for alternating gradient machines were verified over a wide range of operating conditions. Although the electron

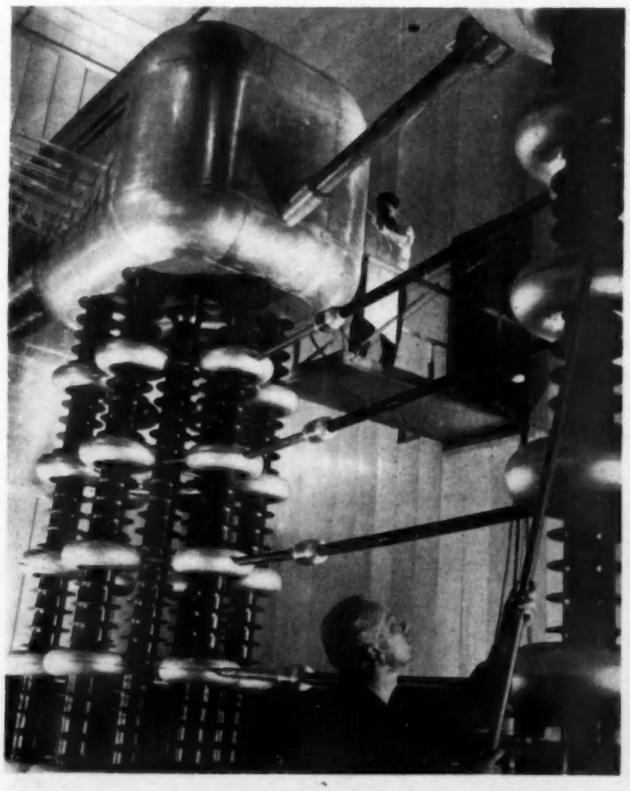


Fig. 3—Cockcroft-Walton generator in the linac building for particle acceleration through 750keV

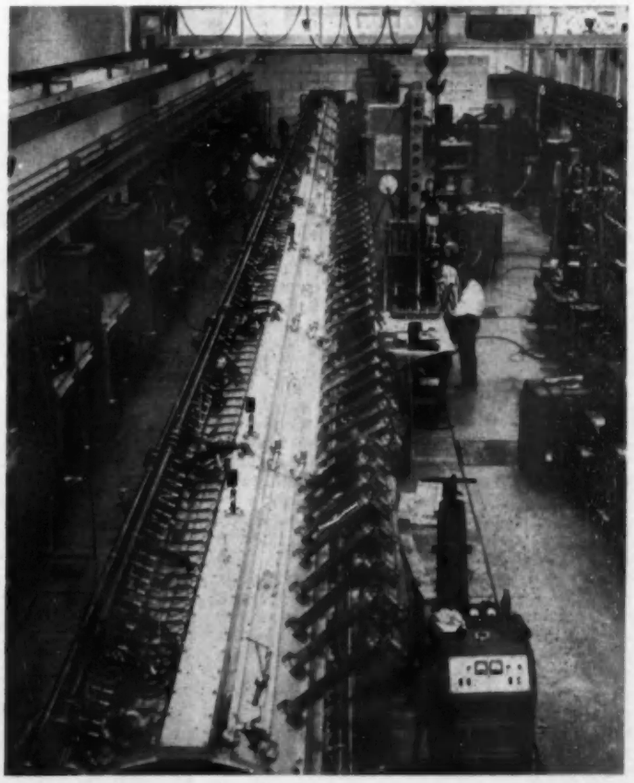


Fig. 4—Overall view of the 50 MeV linear accelerator, looking toward the high-energy end

THE AMERICAN SCENE *(Continued)*

analogue had occupied the A.G.S. staff for several months, the net gain in information contributing to the design and construction of all the alternating gradient machines was considerable, and the 750,000 dollars expended in the analogue represents a valuable investment in the art.

Construction Progress

Following preliminary design studies started in 1952, the A.G.S. was authorised and funds were allocated by the U.S. Atomic Energy Commission in early 1954. Construction was started in late 1955, and digging for the ½-mile circular trench to house the magnet tunnel began in January, 1956. In November, 1956, the staff of the Accelerator Development Department was able to move into the newly-constructed A.G.S. service building, which included electronics and machine shops and laboratories. The total cost of the A.G.S. and its buildings is approximately 31,000,000 dollars.

An over-all plan of the Brookhaven A.G.S. complex is shown in Fig. 1, while Fig. 2 is an aerial view of the construction site. The circular tunnel housing the magnet ring is covered with an earthen dyke as a shielding measure. At the lower left edge of the ring is the Linac Building, which houses the injection system for the synchrotron. The large square structure astride the rear side of the ring is the Target Building, where the experimental equipment for high energy physics research, utilising the synchrotron's proton beam, will be installed. To the right of it is the laboratory and office area. The magnet tunnel opening is about 18ft square, and the ring is ½ mile in circumference. The inward projections in the upper part of the tunnel support the rails of two 20-ton travelling cranes that span the tunnel for handling the magnets and other equipment. The tunnel is now covered with earth, for radiation shielding and to aid the air-conditioning system in keeping the interior temperature constant to ±2 deg. Fah.

Proton Injection

The operation of the alternating gradient synchrotron may be described by following the protons from source to target in Fig. 1. The protons are the nuclei of the most common isotope of hydrogen. Hydrogen gas is supplied to a cold cathode discharge at a pressure of about 1/20,000 of an atmosphere in the ion source shown at the upper left of Fig. 1. Protons from the ionised gas in the discharge pass through a small orifice 1mm or 2mm in diameter in the cathode, whereupon they are accelerated through 750 keV by a Cockroft-Walton generator, shown in Fig. 3. The 750 keV protons are then accelerated to 50 MeV in the High Voltage Engineering linear accelerator, or linac, illustrated in Fig. 4. In the linac, the protons pass through 124 drift tubes of varying length and diameter placed along the axis of a copper-lined tank about 1m in diameter and 110ft long. Fig. 5 shows a linac low-energy tank section with its drift tubes. The tank is both a vacuum enclosure and a cavity resonator which will be driven at 200 Mc/s so that adjacent drift tubes will oscillate in opposite phase electrically.

The protons are " bunched " in the beam like beads on a string, and the spacing of bunches increases with velocity through the linac. Each bunch experiences a forward or accelerating electric field in the gap between drift tubes. While the bunch is passing at constant velocity through the axial hole within the drift tube, the cavity oscillation reverses the electrical polarity of the tubes so that the bunch is again subjected to an accelerating field by the time it reaches the next gap. By proper choice of the voltages, tube lengths, and spacings, bunches are accelerated simultaneously at alternate gaps all along the linac. The peak gap voltages vary from 116kV at the beginning to 890kV at the end, and the cavity requires 3MW of power at 200 Mc/s during the acceleration. The oval shaping of the drift tubes materially reduces the energy required to excite the electromagnetic oscillations within the cavity to given gap voltages and permits higher voltages to be used without electrical breakdown.

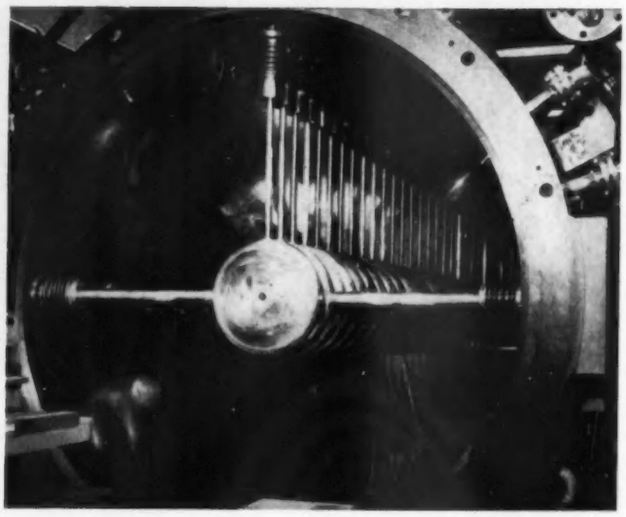


Fig. 5—Internal view of the linear accelerator tank with drift tubes and support stems

The beam is injected at 50·8 MeV into the ring, being conducted from the linac into the main synchrotron ring through an elaborate injection system of debunching, deflecting, focusing, and monitoring gear. At injection into the ring, the beam is about 1·7in diameter and comprises several milliamperes of protons with a total angular spread of 5 milliradians (diverging horizontally and converging vertically) and an energy spread of about 0·1 per cent. Fig. 6 illustrates the junction of the linear accelerator and the main magnet enclosure. The proton beam leaves the linac, which is situated behind the shielding wall and travels along the 4in pipe to the lower right, passing through a series of focusing lenses and steering magnets into the orbit of the synchrotron magnet ring. The pipe extending across the aisle to the left is the exit pipe from an analyser magnet which bends the proton beam through 25 deg. in order to allow for a determination of the energy spread of the protons. Just above the head of the man in the foreground is a set of steering magnets for horizontal and vertical deflections. In the foreground is a viewing box with plastic covers over the drive mechanisms. Inside it are adjustable slits, defined by ¼in copper plates, which are used to align the proton beam and to examine its spatial and angular distribution in order that the correct focusing adjustments can be determined. Inside the viewing box there is also a quartz plate which can be rotated into the beam for visual observation of the beam position and dimensions; the protons impinging upon the quartz produce light, which is observed by means of the television camera in front of the man in the foreground.

(To be continued)

Fig. 6—Junction of the linear accelerator and the main magnet enclosure within the tunnel

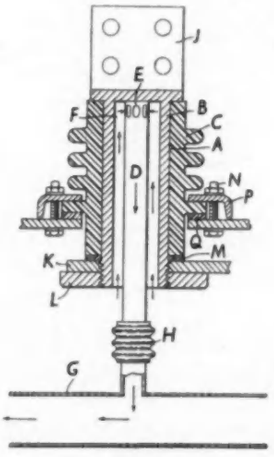
BRITISH PATENT SPECIFICATIONS

The dates printed are those of application and publication on completion. Copies of specifications may be obtained at the Patent Office Sales Branch, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each

ELECTRICAL ENGINEERING

844,381. December 10, 1956.—TRANSFORMERS, The British Thomson-Houston Company, Ltd., Crown House, Aldwych, London, W.C.2. (*Inventor : Gabriel Nelson Leech.*)

This invention relates to fluid-filled electrical transformers. A modern alternator may have a high output, for example, 15kV to 20kV and 10,000A resulting in substantial heat losses in the primary conductors of an associated transformer where they extend through the high-voltage insulating bushings into the transformer casing. Consequently the provision of adequate cooling of the bushings becomes a problem. According to this invention, at least one of the electrical conductors is of hollow construction and closed at the outer end, with a fluid-carrying conduit, preferably of electrical insulating material, extending within the space within the conductor. One arrangement of this kind is shown in the drawing, where a hollow primary conductor



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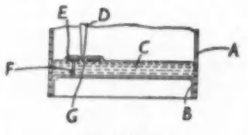
A is closed at its upper end and extends through a casing *B* of the transformer within an insulating bushing *C*. A hollow tube or conduit of electrical insulating material *D* extends coaxially within the electrical conductor *A*. The upper end of the tube is provided with apertures *E* communicating with the space *F* between the outer wall of the insulating tube and the inner wall of the hollow conductor. The lower end of the tube is connected with the main oil extraction line *G* of the transformer through the intermediary of a flexible coupling such as a bellows *H*. The upper end of the hollow conductor is provided with means for releasing air when the transformer is being filled with oil and the transformer is arranged so that a positive static oil head is maintained at the upper end of the hollow conductor. Connection to the electrical conductor is provided for by a terminal *J* at the top end and at the lower end by a conductor bar *K* held by a nut *L*. An oil seal *M* is provided between the bar and the lower end of the insulating bushing. The insulating bushing is retained in position by bolts *N* extending through a split ring *P* acting on the upper surface of a flange provided on the insulating bushing. The lower side of the flange is sealed with the casing by means of a sealing washer Q. In operation the oil flows in the direction of the arrows in the figure, namely hot oil from the windings of the transformer flows upwardly in the hollow conductor through the space *F* between the insulating conduit *D* and the inner wall of the electrical conductor and is drawn through the conduit by way of the apertures *E* by the pump connected to the main oil line and thereafter circulated to an oil cooling device.—*August* 10, 1960.

844,681. June 25, 1956.—LIQUID CATHODE DISCHARGE DEVICES, The British Thomson-Houston Company, Ltd., Crown House, Aldwych, London, W.C.2. (*Inventor : Henry De Boyne Knight.*)

In discharge devices wherein current passes as an electric arc between an anode and a cathode pool, preferably of mercury the level of the mercury in the pool, into which the ignitor electrode dips, may vary from time to time as a result of vaporisation of the mercury during operation, or of any tilting of the device as a whole. When the level varies, the ignition voltage required changes unless the ignitor electrode is designed to operate with varying levels and this renders sensitive operation difficult. The object of the invention is to provide an arrangement in which the effective level of mercury adjacent the ignitor electrode is maintained substantially constant, thereby reducing variation in ignition characteristics. In the construction shown as an example, the arc discharge device consists of a tubular envelope *A* of metal having a flanged base *B* inserted into the end of the envelope and arranged to support a pool type cathode *C* which preferably consists of mercury. An anode (not shown) is supported by a lead insulatingly sealed through a flanged header in the other end of the envelope. An ignitor electrode *D* is supported in a manner not shown from the base *B* so as to be insulated therefrom, and to extend down towards the surface of the pool. Any change in the level of the conducting liquid in the pool caused by vaporisation during operation, or by tilting of the device, could affect the distance between the end of the ignitor electrode and the pool. This, in turn, would affect the ignition energy necessary to ignite an arc in the device. To overcome this disadvantage there is provided a cathode spot anchoring device *E* which consists of a member wettable by the mercury in the pool. When the arc has been started between the cathode and the anode by reason of an



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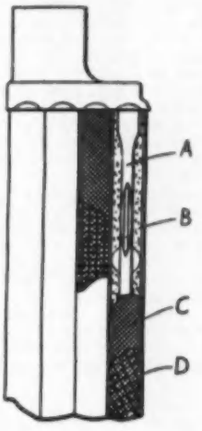
ignition potential applied to the ignitor, the arc remains rooted on the anchoring device and, consequently, the anchoring device should consist of a metal which will withstand the heat of the arc. It has been found that molybdenum is a suitable metal, the molybdenum being treated to render it wettable by mercury by being cleaned electrolytically and fired in hydrogen and then subjected to positive ion bombardment in an arc in mercury vapour. The anchoring device is constituted by a flat plate *E* lying substantially parallel with the base and supported by a vertical post *F*, the plate being located with its lower face substantially in alignment with the upper surface of the mercury level in the pool, the mercury spilling over the upper surface of the plate, which is of a material wetted by mercury. The plate may be provided with an aperture *G* into which the tip of the ignitor projects. When an ignition potential is impressed on the ignitor, the initiating arc passes between the ignitor electrode and the cathode pool by way of mercury adhering to the anchoring device and any gap containing ionised mercury which may be present therebetween. Thus variations in the level of the mercury pool will have little effect on the ignition characteristics of the device.—*August* 17, 1960.

844,544. January 23, 1958.—COVERS FOR ELECTRIC BATTERY ELECTRODES, Aktiebolaget Tudor, 55, Birgerjarlsgatan, Stockholm, Sweden.

In secondary batteries having rod electrodes surrounded by permeable tubular sleeving it is extremely important that the sleevings are formed in such a way as to enable them to retain the active material in close contact with the rod. In order to adapt the retaining tube or sleeving to the changing volume of the active material around the rod, the sleeving has to be sufficiently flexible and elastic. According to this invention the electrode covers consist of electrolyte resistant insulating material permeable to the electrolyte in the accumulator and characterised by having a duplex structure of fibrous material. This consists of a plurality of plies of which the inner ply consists of glass fibre and the outer ply or plies consist of electrolyte resistant fibrous material other than glass. At least one of the plies is a filter or retainer for the active material of the electrode, and at least one ply takes up the expanding forces in the active electrode material and presses it against the conducting member of the electrode. It has been found advantageous to use different types of fabric for the different plies. Thus, for example, if the retaining ply is knitted, it is preferred to make the strengthening ply either woven or braided. In this manner it has been found that as the active material expands, the two plies of different type become bound together by the frictional forces. Referring to the drawing, the electrode is seen at *A* and the active material at *B*. The inner layer *C* of the electrode



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cover is of glass threads and fibres, and the outer layer *D* of threads or fibres other than glass. An electrode sleeving according to the invention has a very high porosity even though the sleeving is made in two or more plies. The capacity of an accumulator of this kind, is, *inter alia*, in proportion to the amount of active material in the cell. For this reason, it is extremely desirable to increase the amount of active material, while maintaining the outer diameter of the electrode rods, and, consequently, also the dimensions of the accumulator. In electrodes made according to the invention the walls of the cover can be made very thin, which means that with a given outer diameter of the electrode sleeving a larger amount of active material can be put in.—*August* 17, 1960.

ELECTRONICS

844,977. February 3, 1958.—ANTI-COLLISION RADIO EQUIPMENT FOR AIRCRAFT, Marconi's Wireless Telegraph Company, Ltd., Marconi House, London, W.C.2. (*Inventor : Jack Wild.*)

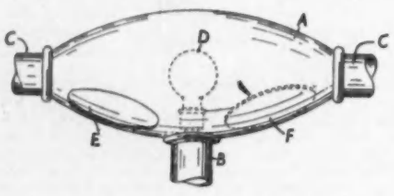
According to this invention the pilot of an aircraft is automatically notified (by receipt of a response signal) if there is another aircraft reasonably near him and flying at a given height, which can be chosen as desired but will normally be his own flying height. To take a practical case, the pilot of an interrogating aircraft flying at, say, 15,000ft, in an area in which the maximum operating height is 50,000ft, desires to be warned of any aircraft flying in his neighbourhood and at or near his own height. He transmits a sequence of at least two pulsed transmissions of which the second occurs time-spaced from the first by a fixed interval portion of (approximately) 100 microseconds plus a height-representing interval portion of, say, 60 microseconds. The fixed interval portion is approximately equal to twice the radio propagation time over 50,000ft—the maximum operating height. The height-representing interval portion represents his flying height (15,000ft), 4 microseconds being assumed allowed for each 1000ft. Any similarly equipped aircraft within radio range receives this sequence. Its equipment is so arranged that, on receipt of the first transmission in the sequence its receiver is rendered inoperative for a period of approximately 100 microseconds so that any second reception of the transmission by reflection at the earth's surface is ineffective. Reception of the first transmission is used to produce a control signal after a delay equal to 100 microseconds plus an added delay dependent on and representative of the flying height of the second aircraft. If the receiving aircraft is also at 15,000ft this control signal will be produced after a delay of 160 microseconds. At this time, however, the receiver will be operative and will receive the second transmission of the sequence from the interrogating aircraft. Such coincidence in time will occur between reception of the second transmission of the sequence and production of the control signal at the interrogated aircraft only if the flying height of the latter aircraft is that which was used to determine the time spacing of the two transmissions in the sequence from the interrogating aircraft. If

such time coincidence occurs, the interrogated aircraft transmits a response signal on a different frequency and this is received by the interrogating aircraft and employed to give its pilot a warning indication.—*August* 17, 1960.

ELECTRIC LIGHTING

844,581. January 13, 1959.—DUAL-CARRIAGEWAY LIGHTING, Jacob Meeuwes Arnold Kroes, 128, Louise de Colignystraat, The Hague, Province of South Holland, the Netherlands.

This invention relates to an anti-dazzle screen with built-in lamps for the illumination of roads with separate tracks. The height of the screen is about 4ft (about 3ft 2in for the opaque screen plate and 10in of open space at the bottom). The screen has a supporting structure formed by tubular posts and tubular horizontal connecting members, the upper ends of the posts and the horizontal connecting members being connected with each other by means of opaque coupling sleeves having lamps arranged therein, and provided with light-transmitting apertures such that light can only radiate in the direction of traffic movement on each track. The opaque coupling sleeves *A* (see drawing), of ellipsoidal form, are mounted at intervals of about 16ft on the vertical tubular posts *B* and in line with the horizontal tubular connecting members *C*. The screen plates, which have a thickness of about ¼in, are made of a reinforced elastic material, e.g. wire netting filled with rubber. However, other suitable opaque materials, such as synthetic materials with or without reinforcement, may also be used. The vertical posts rest on pedestals of concrete on the road surface.



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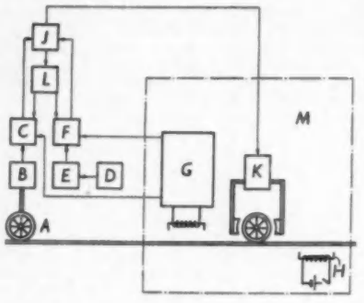
The lamp *D* radiates exclusively through the apertures *E* and *F* in the coupling sleeves. The apertures are on opposite sides of a vertical plane containing the major axis of the ellipsoid and are disposed so as to transmit light in opposite directions and obliquely with respect to the said plane, the apertures being invisible to drivers of oncoming vehicles. The strongest illumination will be received by the traffic lane meant for the highest speed, whereas with a light radius of about 25ft there remains sufficient illumination for the slower traffic lane or lanes. The light sectors formed at intervals of 16ft will thus have an overlap of about 9ft. Lamps of small power are sufficient for obtaining a very effective and subdued illumination of the road surface and of the objects thereon, which renders the use of headlights superfluous and can never give rise to dazzle. If nevertheless a driver should use his full headlights, the screen plates will prevent dazzling of the drivers of oncoming cars.—*August* 17, 1960.

RAILWAY SIGNALLING

845,254. September 5, 1958.—TRAIN SPEED CONTROL AND CAB SIGNALLING EQUIPMENT, Société Technique pour l'Industrie Nouvelle S. A. "Stin," 2, Rue de Jura, Vevey, Switzerland.

This invention is concerned with train control and cab signalling apparatus for the initiation of operations, for example brake application or the sounding of alarm, on a rail vehicle when it is in motion. It proposes the use of two electronic counters, one counting electrical pulses which are proportional in number to the rotations of a wheel of the vehicle, the other counting electrical pulses of a constant repetition rate. An example of apparatus constructed in accordance with the invention is shown in the drawing. A wheel *A* of the vehicle produces, for example by acting on a non-rotating coil, a series of electrical pulses in a pulse generator *B*, the number of pulses being proportional to the number of rotations of the wheel. These pulses are counted by an electronic counter *C*. A constant frequency electronic oscillator *D* feeds a pulse shaper *E* which produces a series of pulses at a repetition rate proportional to the frequency of the oscillator, and these pulses are counted by an electronic counter *F*. The generator *B* and oscillator *D* operate continuously but the counters *C* and *F* are, in their normal rest positions, not operating. The starting of the two counters is caused by a signal from the detector *G* when the vehicle passes over the electromagnet *H*. Each counter is arranged so that when its count reaches a predetermined figure, a signal is passed to a sensing device *J*. This device sends out a signal of one of two kinds, depending on the order in which it receives the signals from the two counters. If that from *C* is received first, then the device causes the equipment *K*, to apply the brakes, since this indicates that the speed of the vehicle is higher than is permitted for the stretch of track over which



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the vehicle is passing. If the signal from *F* arrives first the device passes a signal to a resetting device *L* which returns the two counters to zero ready for the next operation of the apparatus. The operation, initiated by the completion of the counting operation when the train speed is below the permitted maximum, could be the initiation of a further counting operation which then terminates in a return of the apparatus to its initial position or an application of the brakes, as before. The apparatus contained within rectangle *M* for initiating the action is of known kind.—*August* 17, 1960.

AIRCRAFT

844,614. November 5, 1957.—TANDEM-WINGED AIRCRAFT, F. G. Miles, Ltd., Shoreham Airport, Shoreham-by-Sea, Sussex, George Herbert Miles, of the company's address, Donald Lambert Brown, Farnborough Place, Farnborough, Hampshire.

It has been previously proposed to provide a tandem-winged aircraft with a forward wing structure in the form of a stabilising aerofoil which is mounted above and in front of the centre of gravity of the aircraft whereby the lift and drag applied to the centre of pressure of this wing have an appreciable moment relatively to the transverse axis through the centre of gravity, which tends to pull up the nose of the aircraft and consequently gives it a satisfactory pendula stability. It has also been proposed to control the lift of the forward wing of the aircraft by providing for the incidence of at least a part to be adjustable from the pilot's seat, and for this purpose it may be pivoted about a transverse axis passing through its centre of pressure. In contra-distinction from the object to be achieved by the above construction, which is adaptable only to aircraft of relatively low speed, the present invention is particularly concerned with high speed aircraft and, therefore, the introduction of any appreciable moment relative to the transverse axis passing through the centre of gravity is to be avoided. With continual increase of the speed and altitude performance of aircraft, designers are faced with the problem of providing greater longitudinal stability and control to overcome the difficulties arising from the displacement of the centre of pressure which occurs at sonic speed, &c., and the object of the invention is to provide an aircraft having improved longitudinal stability and control. The invention consists of an aircraft in which the forward wing is of less area than the rearward wing, the forward wing being mounted for restricted rotation about an axis transversal of the longitudinal axis of the aircraft to provide longitudinal control and is situated, when the aircraft is horizontal, close to the horizontal plane passing through the centre of gravity of the aircraft. It is preferred to make the area of the forward wing about one-quarter to one-third the area of the rearward wing. In the case of high-speed aircraft it is preferred to provide both wing structures with a low aspect ratio and a thickness/chord ratio not exceeding 7½ per cent, but in the case of low speed aircraft this would not be applicable. Also either or both wings may be fitted with lift increasing devices if desired, while the forward wing in particular may be arranged to incorporate means of controlling the flow of the boundary layer.—*August* 17, 1960.

Catalogues and Brochures

ENGLISH ELECTRIC VALVE COMPANY, Ltd., Chelmsford, Essex.—Valve replacement index showing E.E.V. equivalents for valves of various manufacturers and for Service valves; also a catalogue of voltage stabilisers and reference tubes, and a leaflet on the CR192 v.h.f. power tetrode. The leaflet is one of a series giving details of E.E.V. transmitting tetrodes, with maximum ratings, typical operating conditions, and installation notes.

THE BELMOS COMPANY, Ltd., Bellshill, Lanarkshire.—Leaflet PA.88 : 10 entitled "The Problem of Short-Circuits Related to the Busbars and Apparatus on Group Motor Control Boards," (in the range 400V–600V). The leaflet, it is stated, endeavours to set out what the problems are, and to show that, while high values of prospective short-circuit can undoubtedly occur on some major installations, they do not necessarily apply to the majority and that to specify fault values which cannot arise means costly control gear which is unwarranted by facts.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

Mon., Sept. 12.—BOLTON BRANCH: Railway Hotel, Trinity Street, Bolton, "Automatic Temperature Control of Space Heating," L. G. Barnfield, 7.45 p.m. ★ CENTRAL LONDON BRANCH: White Hall Hotel, Bloomsbury Square, London, W.C.1, Film Show, 7.15 p.m. ★ NORTH WEST LONDON BRANCH: Century Hotel, Wembley, Open discussion on "Domestic Electricity—Friend or Foe?" 8.15 p.m.

Tues., Sept. 13.—ALDERSHOT AND DISTRICTS BRANCH: Queens Hotel, High Street, Aldershot, "Power Station Cabling," J. Saner, 8 p.m. ★ CHESTER AND DISTRICT BRANCH: Westminster Hotel, City Road, Chester, "Basic Principles of Resistence Welding," G. A. Spencer, 7.45 p.m. ★ GLASGOW BRANCH: Visit to Loch Sloy Hydro-Electric Power Station, 7.30 p.m. ★ NEWCASTLE UPON TYNE AND DISTRICT BRANCH: Roadway House, Oxford Street, Newcastle upon Tyne, "Electromagnetic Drives," J. Bailey, 7.30 p.m. ★ SOUTH WALES BRANCH: Park Hotel, Park Place, Cardiff, "Activities of the A.S.E.E.," E. A. Bromfield, 7.30 p.m. ★ YORK BRANCH: Royal Station Hotel, York, "The Activities of the A.S.E.E.," E. K. Brittain, 7.30 p.m.

Wed., Sept. 14.—WOLVERHAMPTON AND DISTRICT BRANCH: Chamber of Commerce, District Bank Chambers, Lichfield Street, Wolverhampton, "Control Centres in Modern Industry," B. Wilson, 7.45 p.m. ★ BIRMINGHAM BRANCH: Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham, 2, "Flameproofness and Intrinsic Safety," W. Bevan Whitney, 7.30 p.m. ★ LUTON BRANCH: Luton College of Technology, Park Square, Luton, "The House of Commons," Charles Hill, 8.15 p.m.

Fri., Sept. 16.—STOKE AND CREWE BRANCH: Royal Hotel, Crewe, "Control Centres for Modern Industry," H. B. Davies, 7.30 p.m.

BIRMINGHAM SCIENCE MUSEUM

Thurs., Sept. 29.—Museum of Science and Industry, Newhall Street, Birmingham, 3, "Live Steam Operation of Five Engines," evening until 9 p.m., additional to regular "Steam Week-ends."

BRITISH INTERPLANETARY SOCIETY

Mon., Sept. 12.—Lancaster Room, Caxton Hall, London, S.W.1, "Spaceflight—Hints, Pitfalls and Problems," L. J. Carter, 7 p.m.

Tues., Sept. 13.—Lancaster Room, Caxton Hall, London, S.W.1, "Special Points in Lectures to Schools," N. H. Langton, "Preparing a Technical Paper," L. R. Shepherd, 7 p.m.

Sat., Sept. 17.—Tudor Room, Caxton Hall, London, S.W.1, "Programme for the Surface Exploration of the Moon," P. A. E. Stewart, 6 p.m.

COLLEGE OF ADVANCED TECHNOLOGY

Thurs. and Fri., Sept. 22 *and* 23.—College of Advanced Technology, Gosta Green, Birmingham, 4, Joint Symposium with the Institution of Gas Engineers, and the Society of Chemical Industry, Corrosion Group on "The Protection of Gas Plant and Equipment from Corrosion," 9.30 a.m.

INSTITUTION OF LOCOMOTIVE ENGINEERS

Tues., Sept. 20.—Lecture Hall, Institution of Mechanical Engineers, 1, Birdcage Walk, London, S.W.1, Presidential Address, D. C. Brown, and Ordinary General Meeting, 5.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

Wed., Sept. 14.—EASTERN GRADUATES' SECTION: Visit to the Shell Installation at Royston, 7.30 p.m.

Sat., Sept. 17.—NORTHERN IRELAND GRADUATES' SECTION: Visit to Maydown Industrial Estate, Londonderry, 8 p.m.

Tues., Sept. 20.—SOUTH WALES BRANCH: South Wales Institute of Engineers, Park Place, Cardiff, Chairman's Address, T. G. Dash, 6 p.m.

INSTITUTION OF PLANT ENGINEERS

Wed., Sept. 14.—WESTERN BRANCH: Royal Clarence Hotel, Exeter, "Motorway," film and talk on the construction of the M.1, 7 p.m.

Thurs., Sept. 15.—BLACKBURN BRANCH: Castle Hotel, Blackburn, "New Developments in Fuel and Power Technology," M. W. Thring, 7.30 p.m.

Wed., Sept. 21.—KENT BRANCH: King's Head Hotel, High Street, Rochester, "Insulation of Factories and Buildings," N. Foster, 7 p.m.

Thurs., Sept. 22.—MERSEYSIDE AND NORTH WALES BRANCH: Exchange Hotel, Liverpool, "Some Engineering Problems with Chemical Plant," J. C. Veale, 7.15 p.m.

THE INTERNATIONAL ASSOCIATION FOR CYBERNETICS

Sun. to Thurs., Sept. 11 *to* 15.—Namur, Belgium, Third International Congress on Cybernetics.

SOCIETY OF CHEMICAL INDUSTRY

Wed. to Fri., Sept. 21 *to* 23.—PLASTICS AND POLYMER GROUP: William Beveridge Hall, Senate House, University of London, W.C.1, Symposium on "High Temperature Resistance and Thermal Degradation of Polymers."

SOCIETY FOR WATER TREATMENT AND EXAMINATION

Wed. to Fri., Sept. 14 *to* 16.—St. Peter's Hall, Oxford, Autumn Meeting, 1960.

LOST

On or about April 1st this year, between Lombard Street and the Metropolitan Police Boundary, a large quantity of Treasury Notes, Bonds, Sleep, Hope etc. by a Firm who forgot that **ASSOCIATED LEAD** supply: **RED LEAD PAINTS AND 'RUSTODIAN' CALCIUM PLUMBATE PAINTS** as well as every other form of Lead and Antimony, in any quantity. Firm concerned prefers to remain anonymous.

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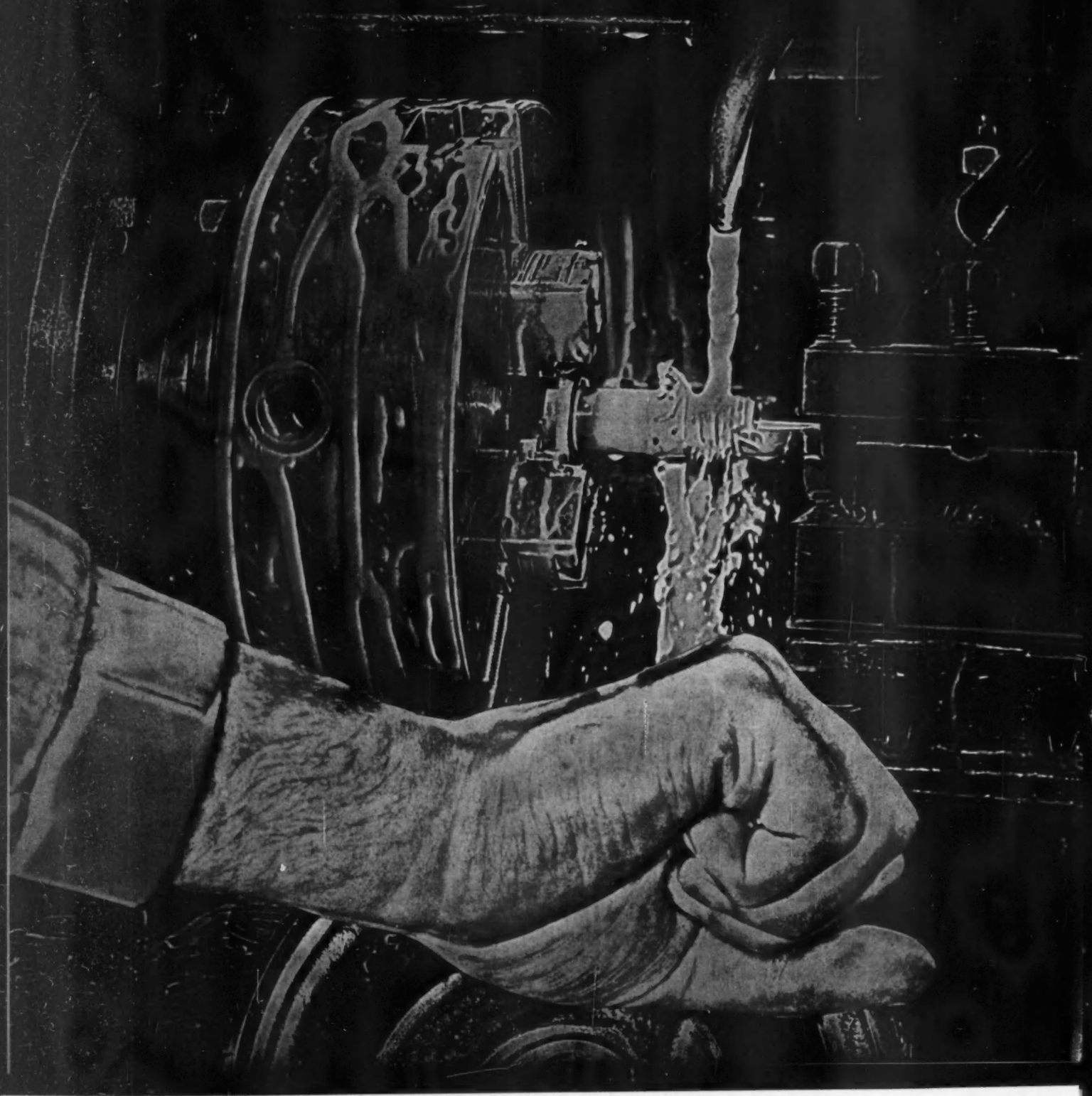

With new Shell Dromus Oils

Most modern soluble cutting oils contain phenolic compounds used as coupling agents between the oil and the emulsifier, for better blending and easier mixing. These phenolic compounds can cause skin irritation, especially where modern high-speed machines are used and the emulsion can concentrate, through the evaporation of water, above the safety level.

Shell research chemists have been working on this problem, which has been causing some concern to Management. After considerable research, Shell Dromus Oils have been reformulated and these new cutting oils now produce bland emulsions, which considerably reduce the risk of skin trouble to operators.

The real difficulty was to find a new coupling agent to replace the phenolic compounds, and Shell finally used what their chemists know as a higher fatty alcohol complex. This solved one problem, but presented another. The new coupling agent was volatile at the high temperatures normally used in blending processes. Further research found a solution to this problem by designing and installing new plant. The new Dromus Oils are every bit as efficient as before and cost no more. They put Management in the welcome position of being able to minimise working hazards at no extra cost. And machine men need no longer be so worried about skin troubles.

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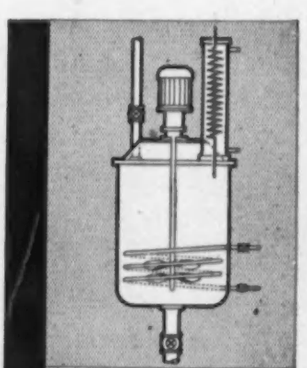
Shell chemists in the U.K., in Holland and in the U.S.A., prepared and examined hundreds of experimental soluble oils, and established that certain combinations of fatty alcohols could be used in place of phenolic compounds with no loss of efficiency. They set to work to discover the best combination and developed a higher fatty alcohol complex which fitted exactly. Then they realised that to blend this new coupling agent into soluble oils would require special plant and new blending techniques.

Exhaustive testing of blend stability, emulsion stability, anti-corrosion and machining properties led to selection of the most promising blends. A pilot plant was set up to produce batches of these for use in field trials.

This field testing and final development proceeded for two years whilst production plants were erected at points so chosen as to give the most economical and rapid delivery throughout the United Kingdom.



This is the blending kettle. The reflux condenser beside the stirrer motor prevents the loss of constituents volatile at the blending temperature.

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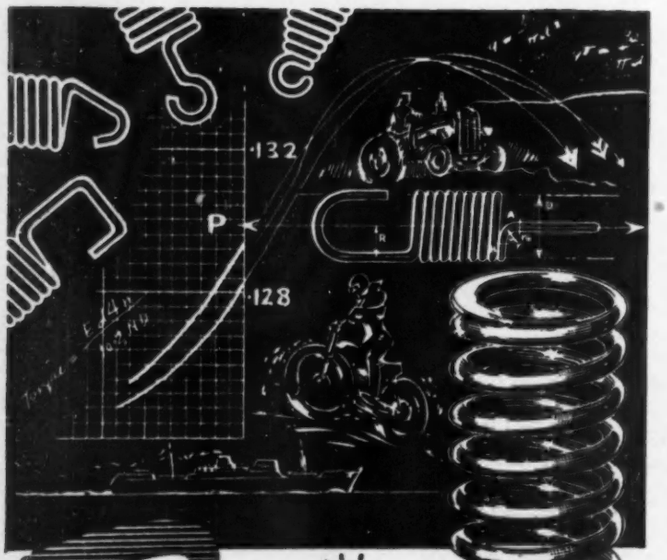

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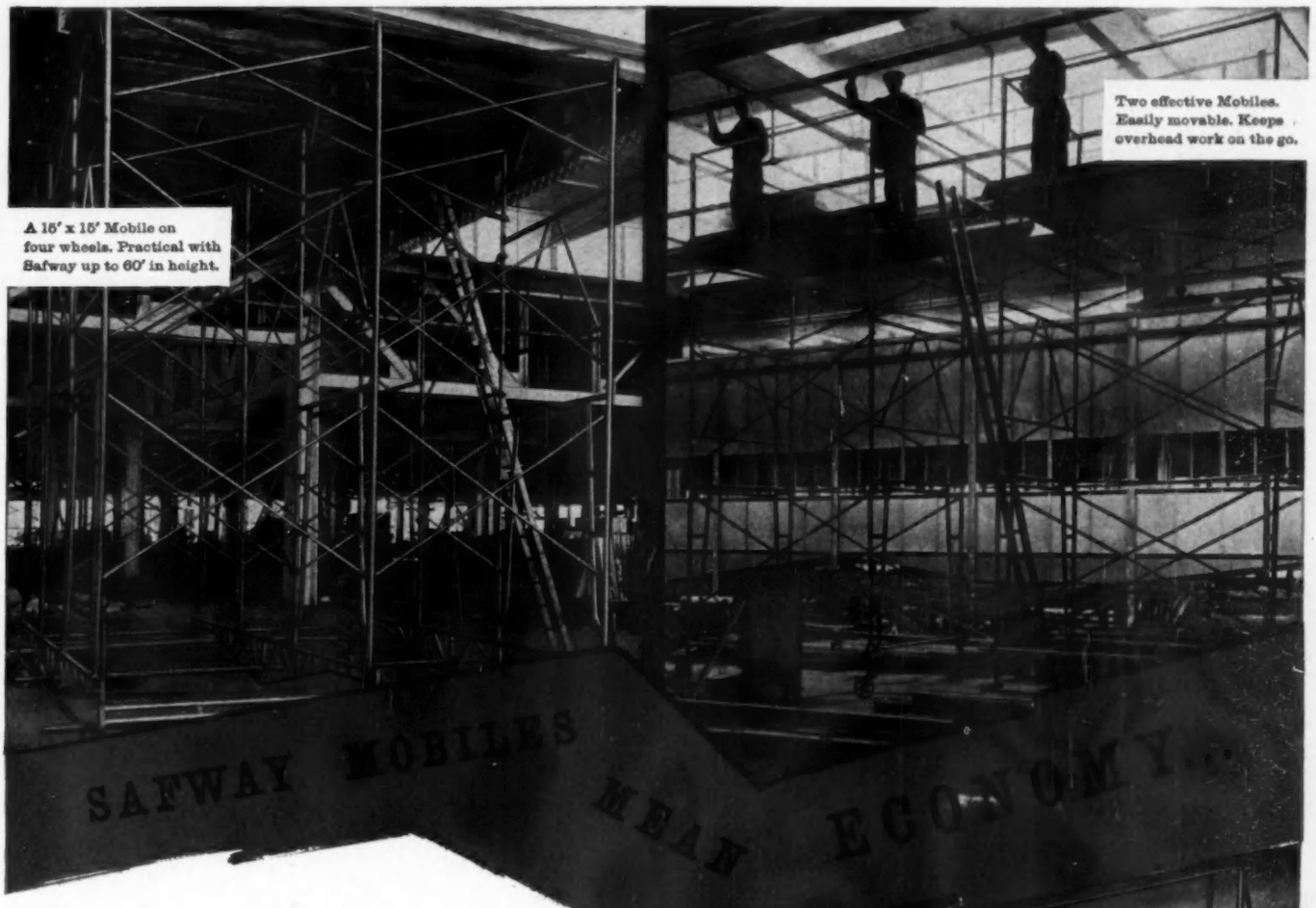

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The adjoining SAFWAY-in-action photographs, taken at the site of the new Assembly Division, Ford Motor Co. at Dagenham, illustrate well one of the basic advantages of Safway scaffolding . . . the ease and speed with which the standard units may be assembled on the spot to produce safe, stable, mobile platforms, easily adjustable for height. Delays and costs are cut to the minimum. **Versatility PLUS.** Remember the above is just a bonus benefit to the SAFWAY user . . . these special structures are quickly built . . . and when finished with, quickly dismantled for re-use. SAFWAY Scaffolding is faster 'up-and-down' and is load-bearing too—first for Versatility.

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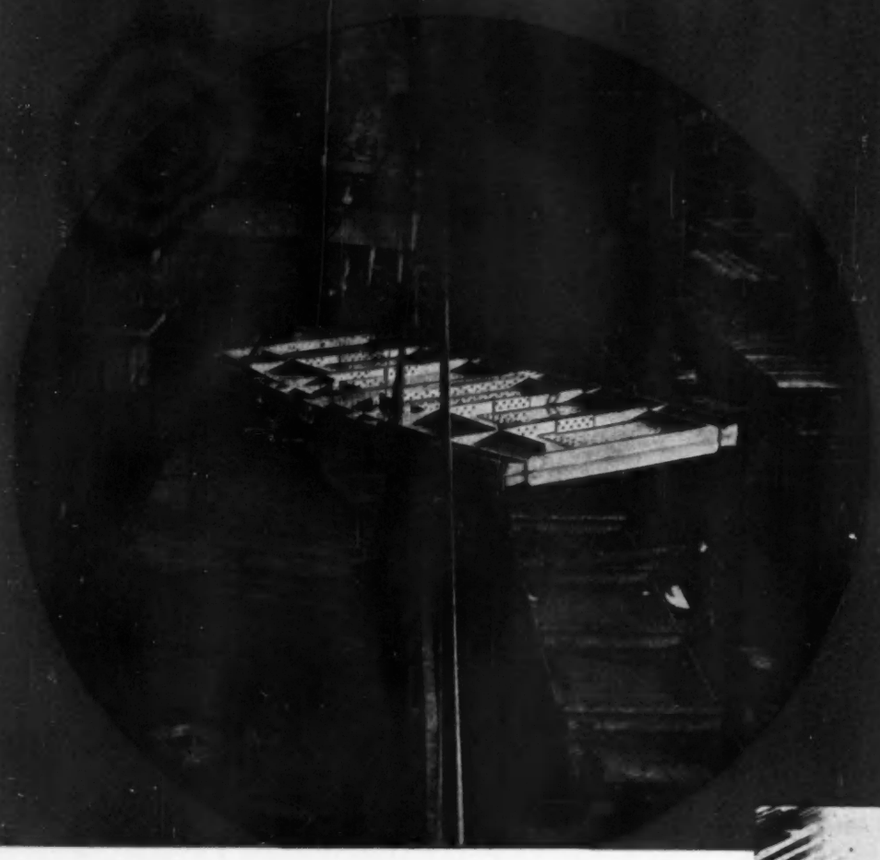
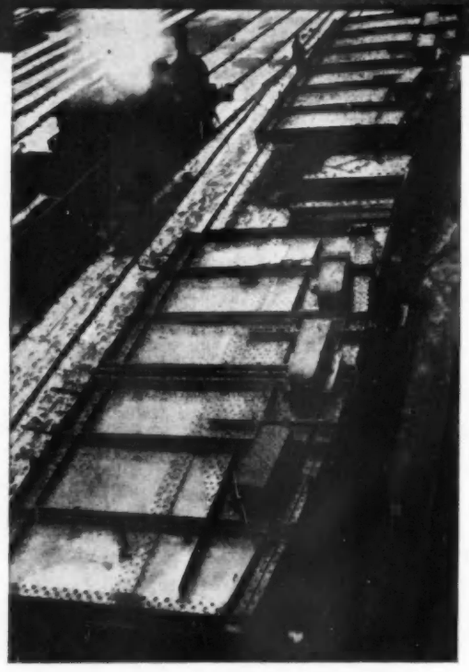


Shipping bridge members for erection overseas



In addition to building bridges in any part of the world, Dorman Long export fabricated bridge members for erection locally, often by semi-skilled labour.

The illustrations show bridge girders on the way to Saigon, for bridges at Dong Nai and Saigon.

Other fabricated steelwork recently sent overseas includes heavy steelwork for the melting shop of the Durgapur steelworks, and fabricated members for the Auckland Harbour Bridge and the Rohri Channel Bridge, Sukkur, West Pakistan.

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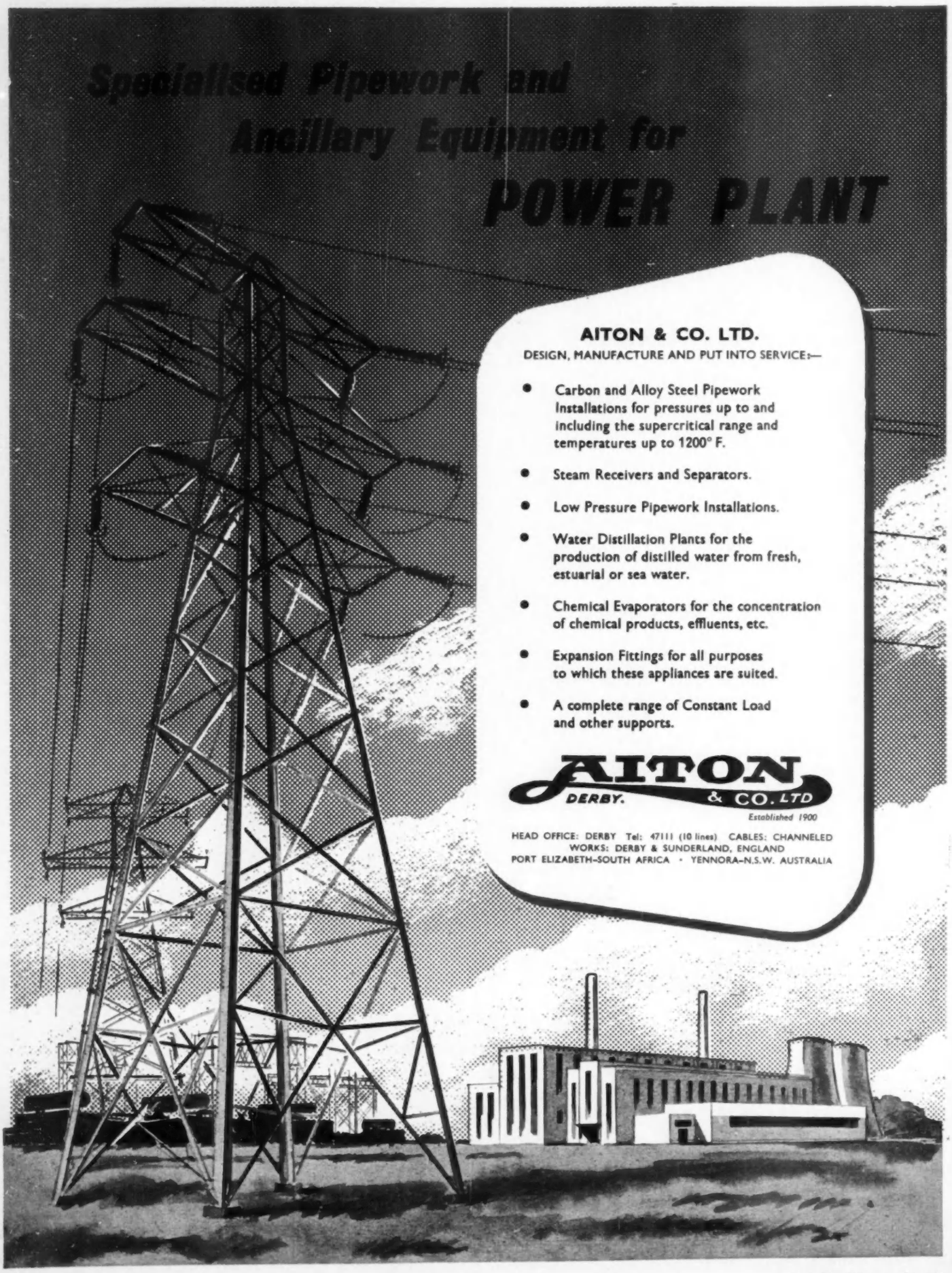
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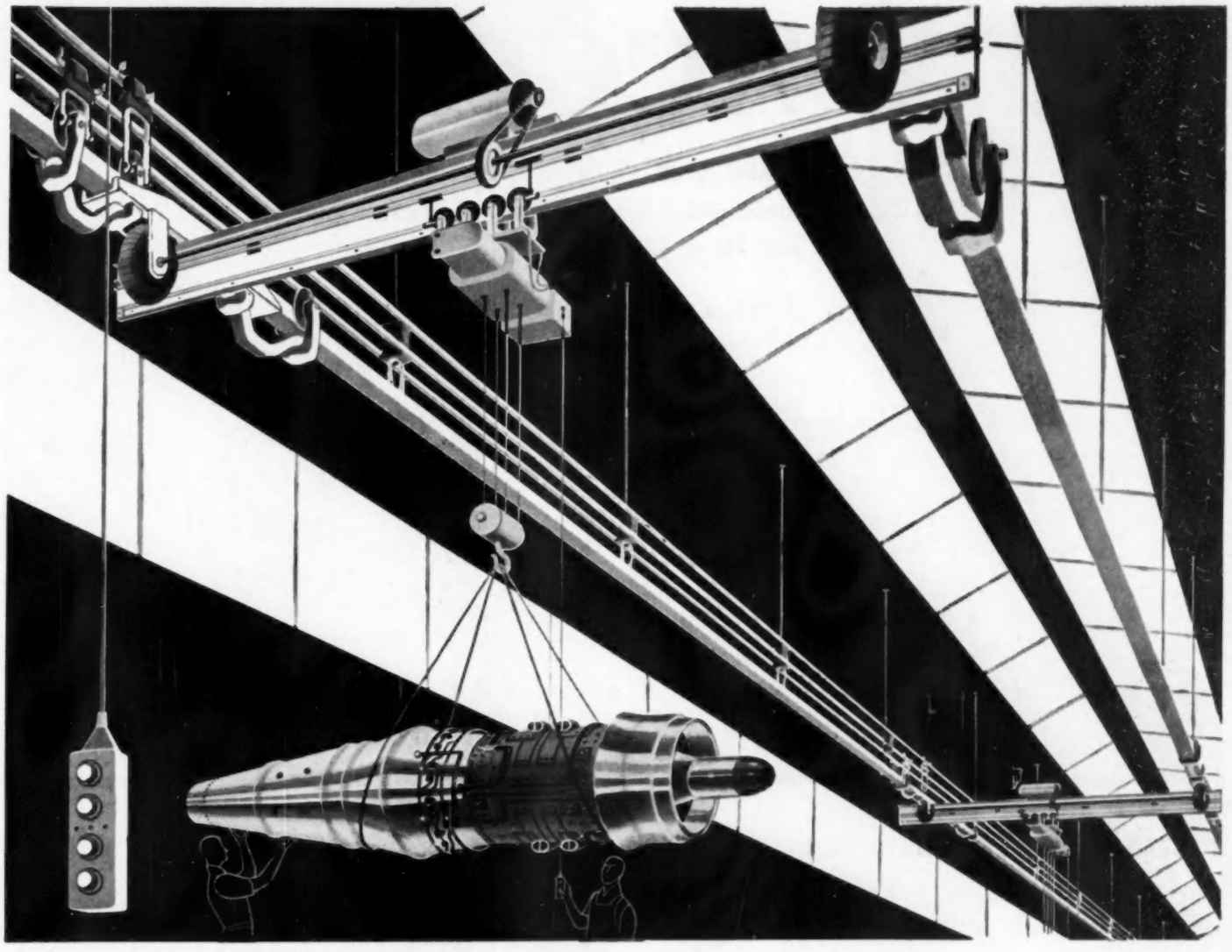

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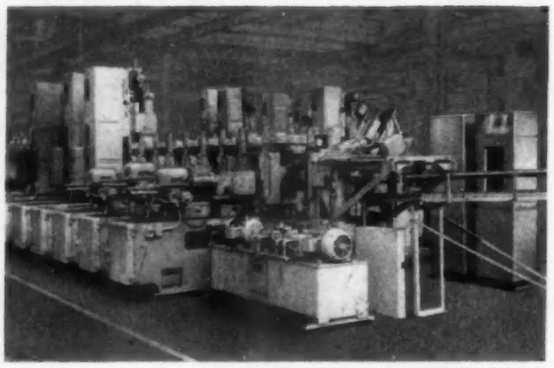

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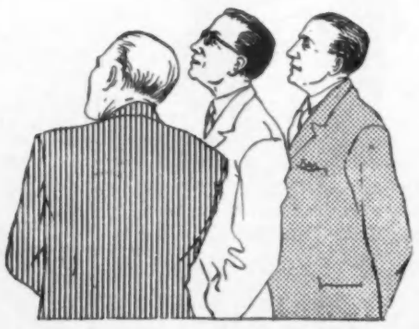

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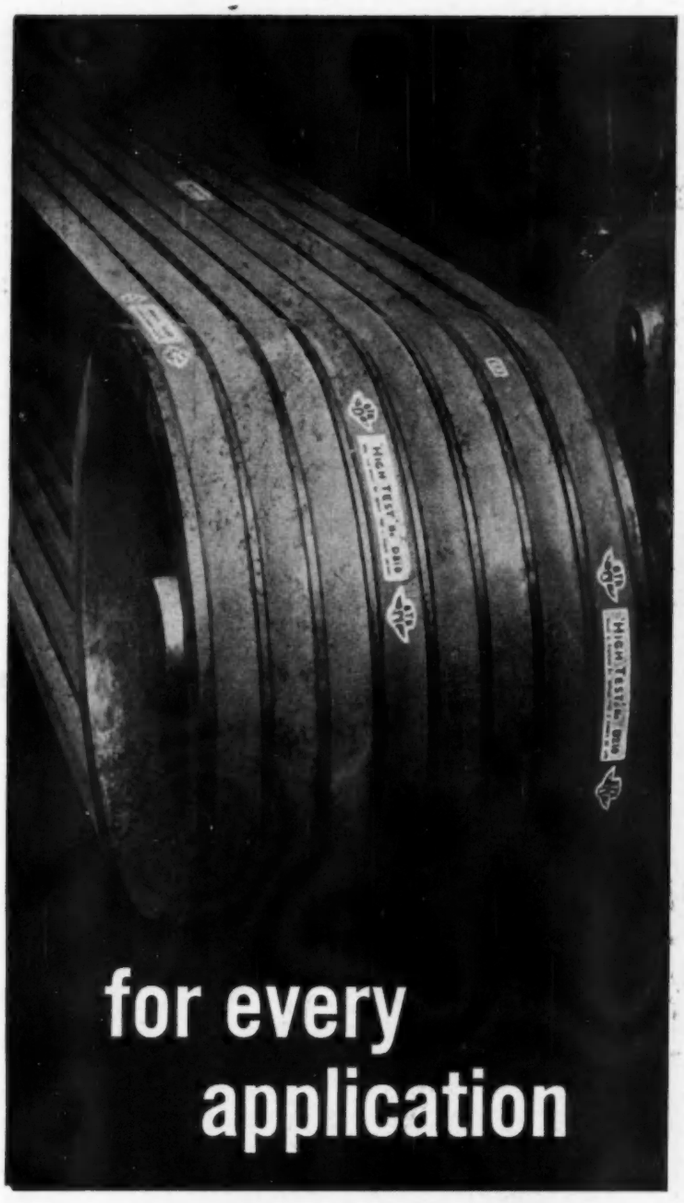

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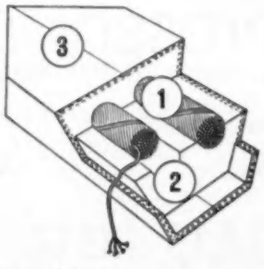

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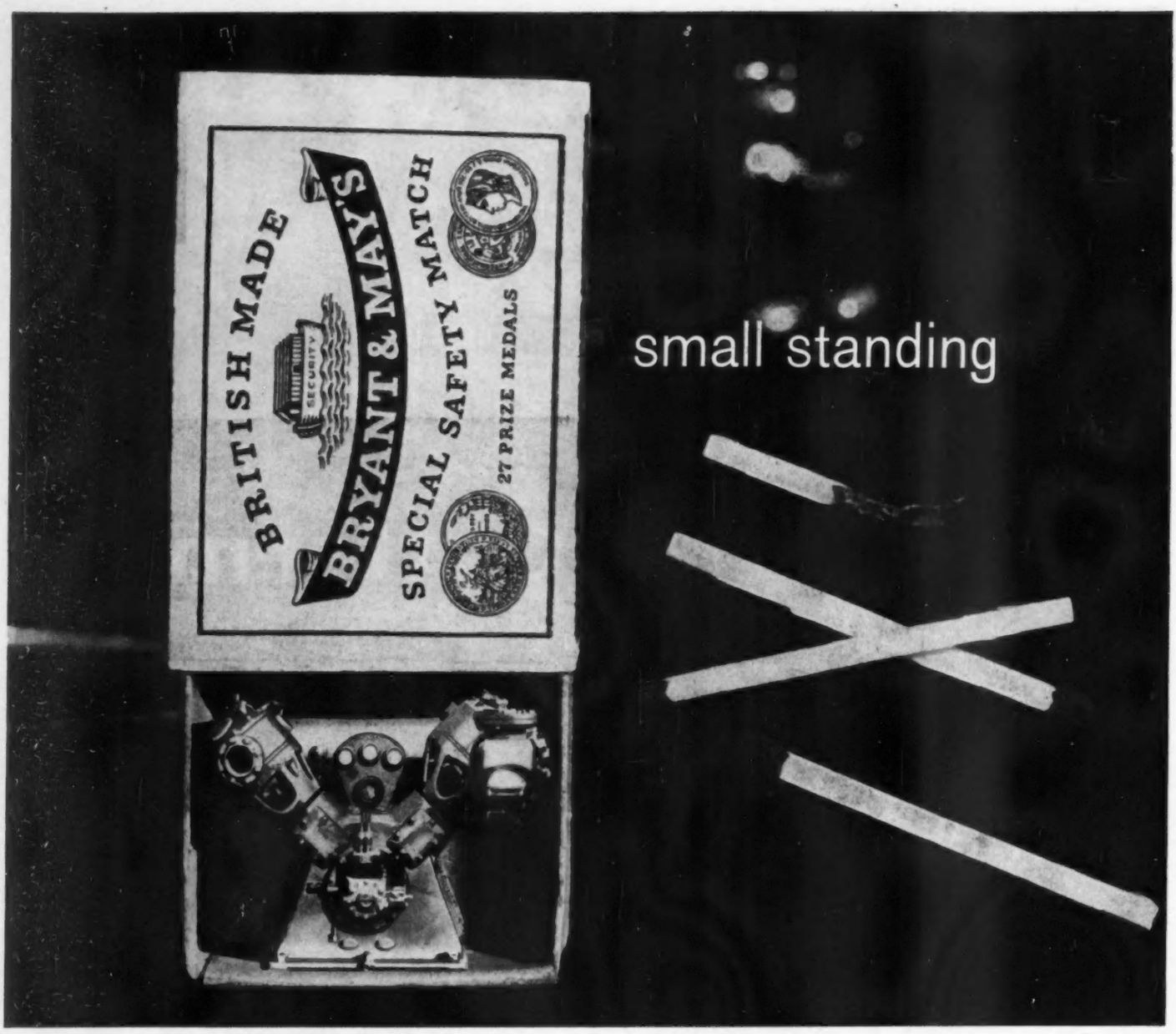

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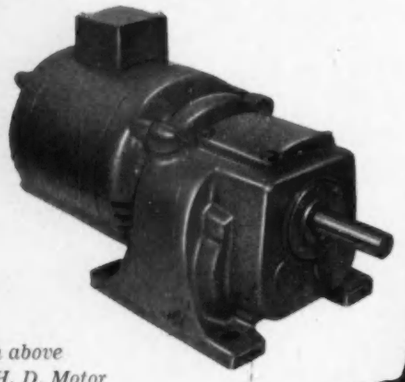

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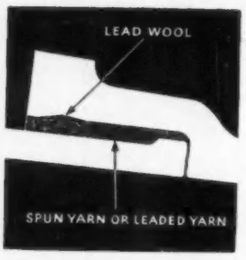

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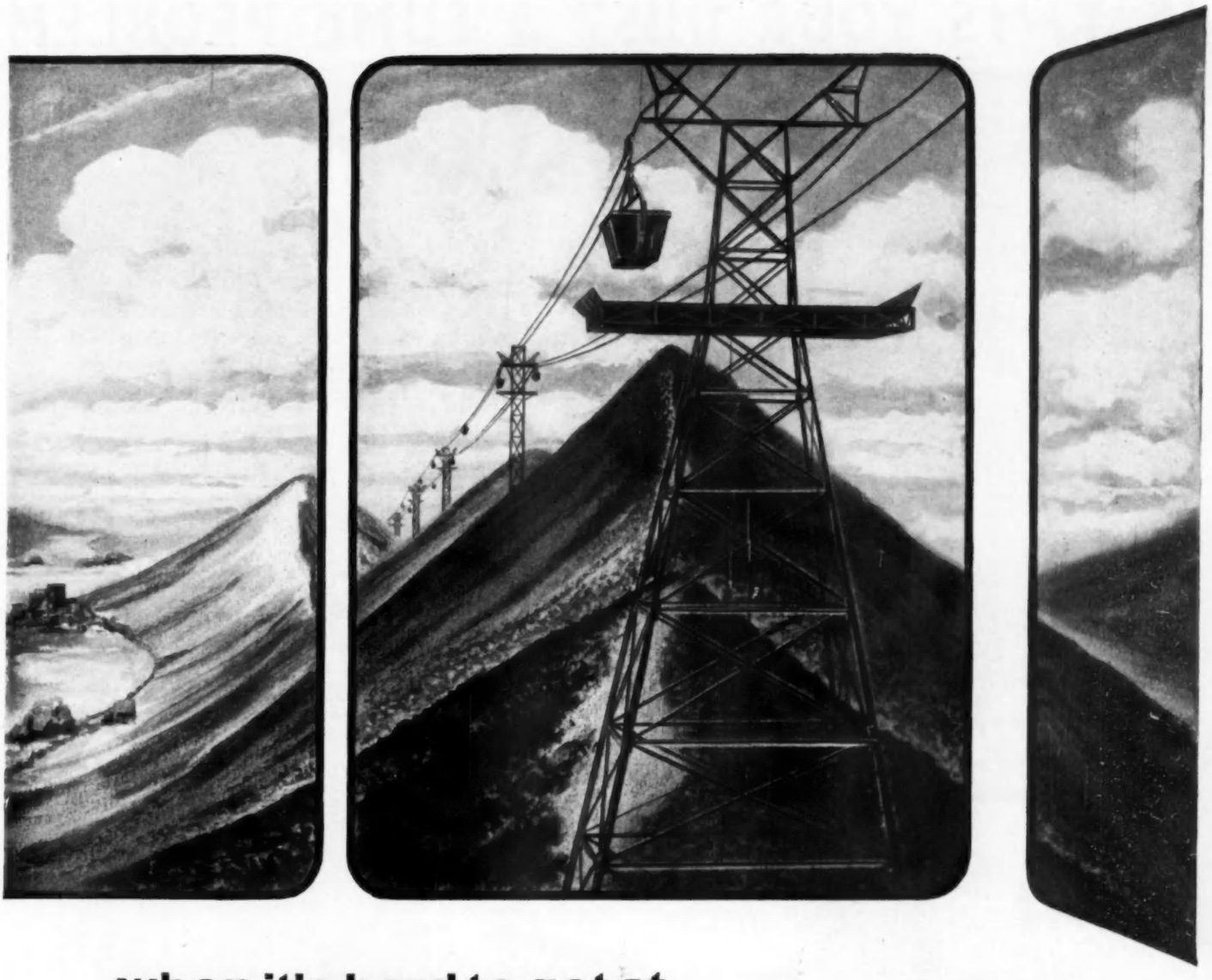

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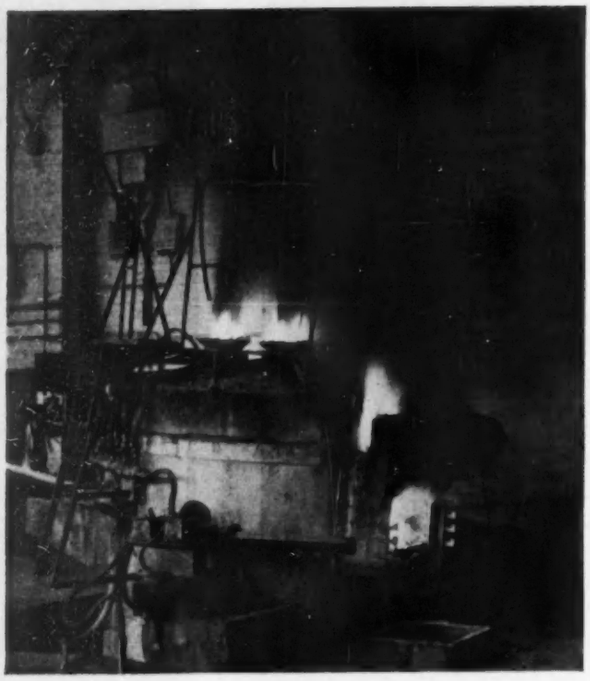

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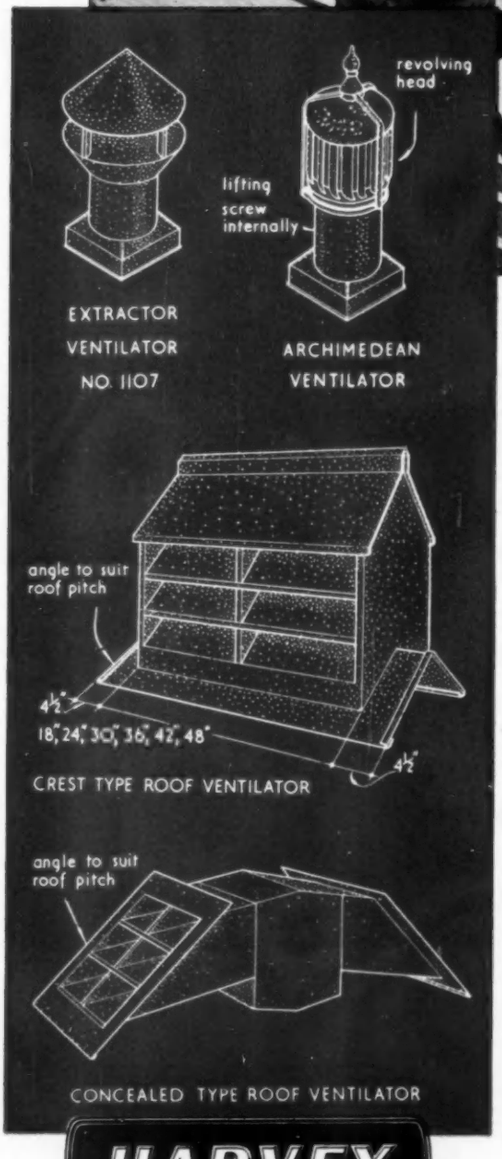

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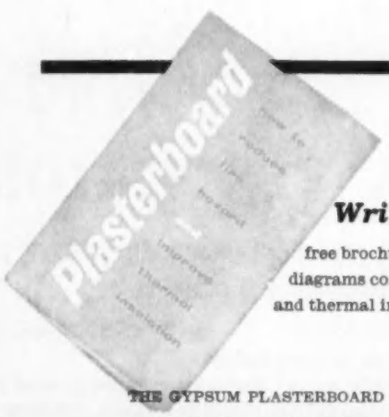

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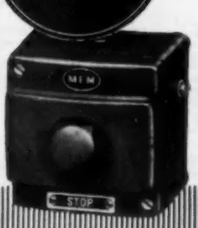

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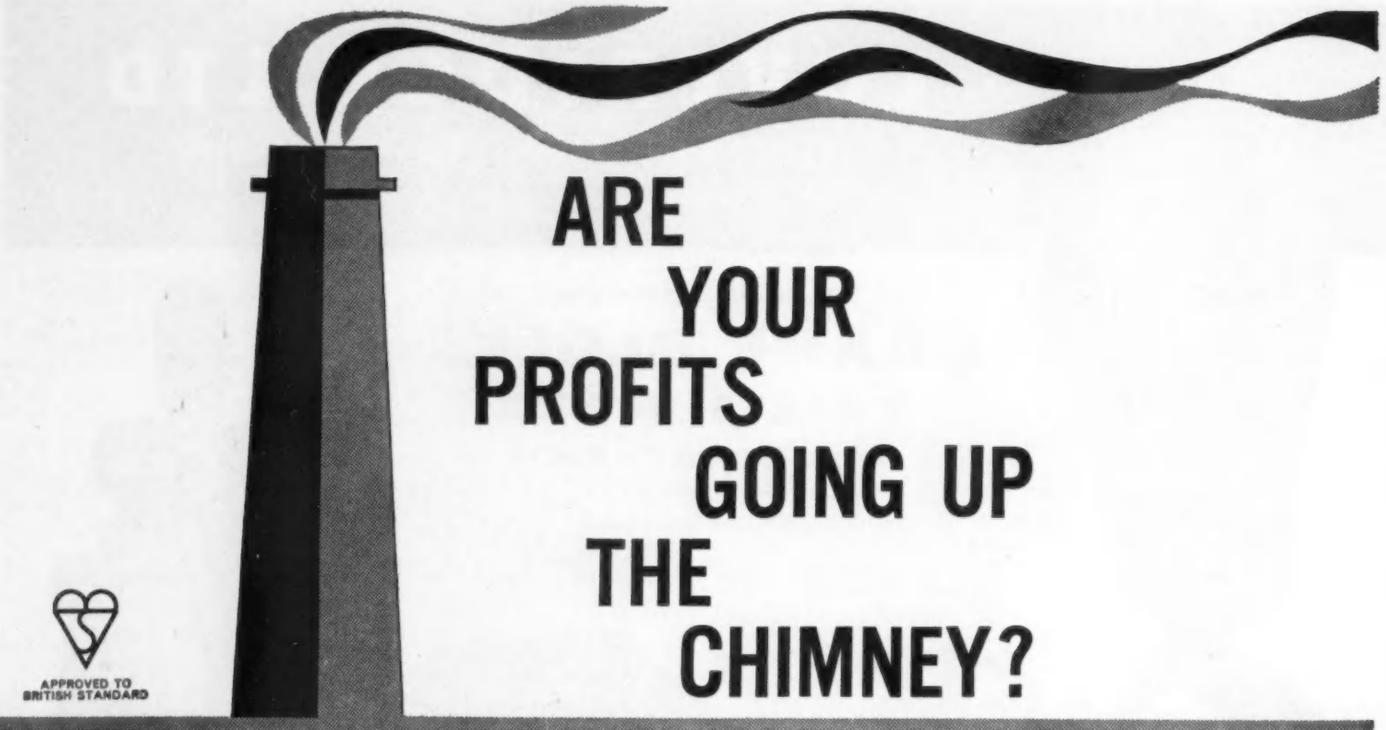

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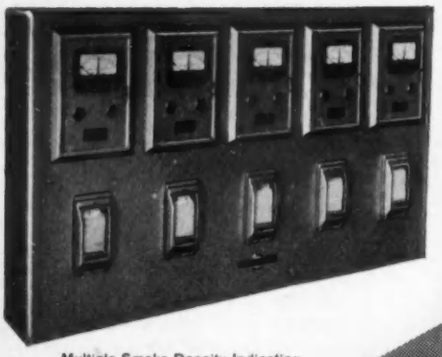

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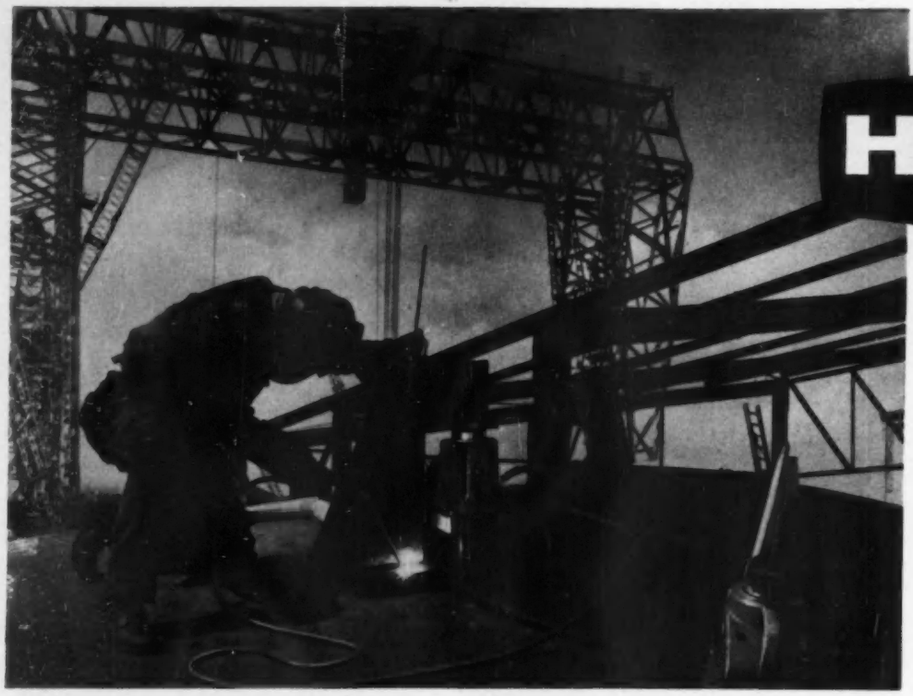

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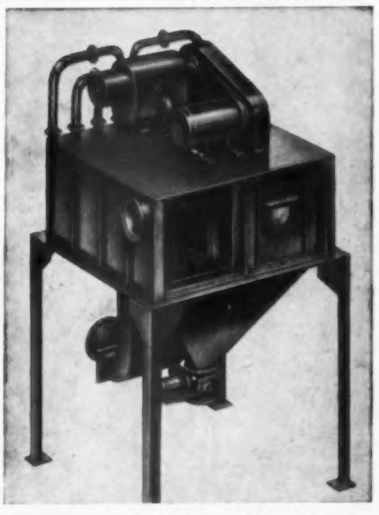

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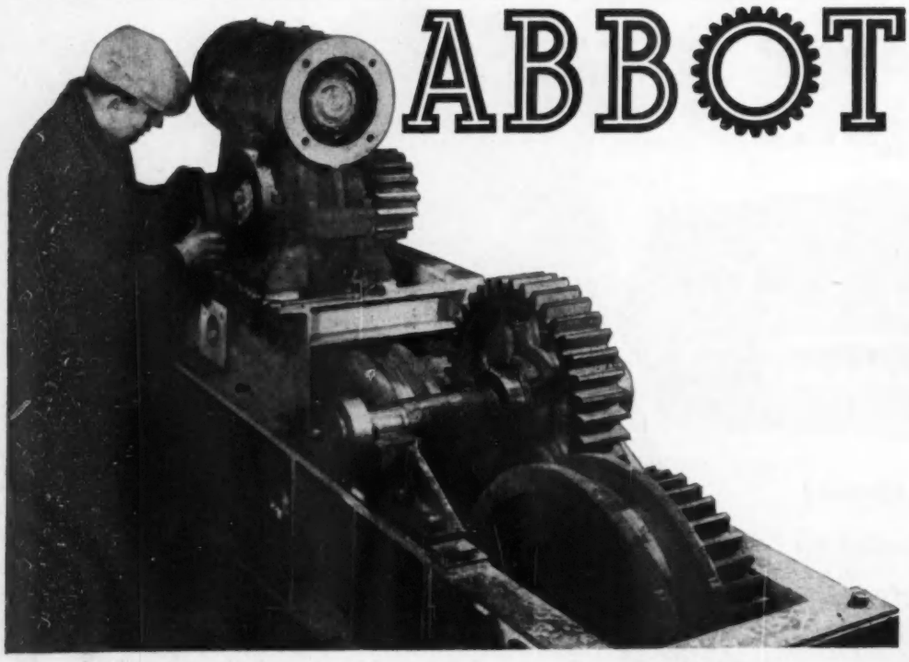

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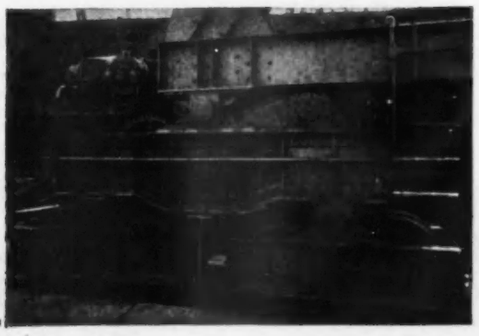

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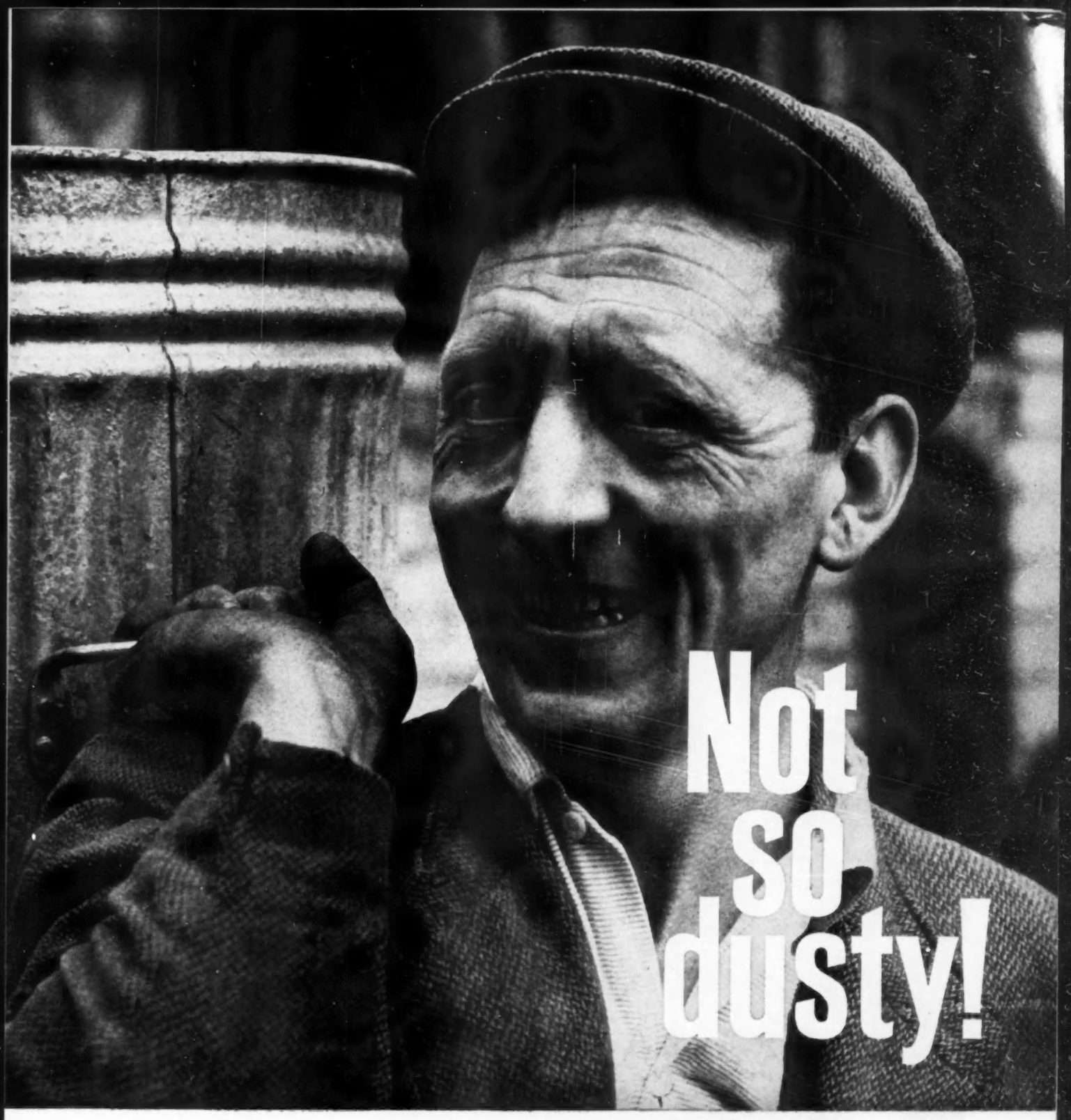

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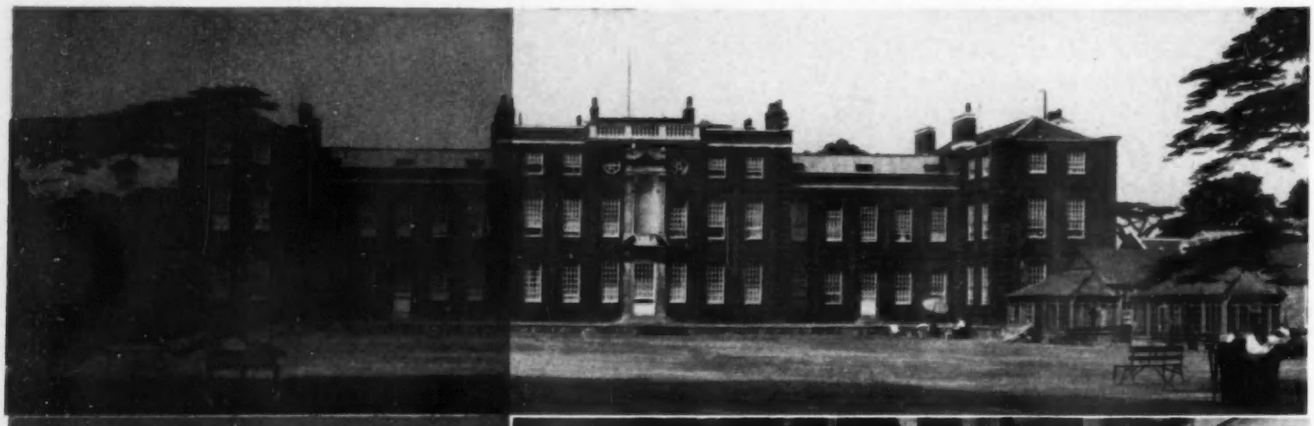

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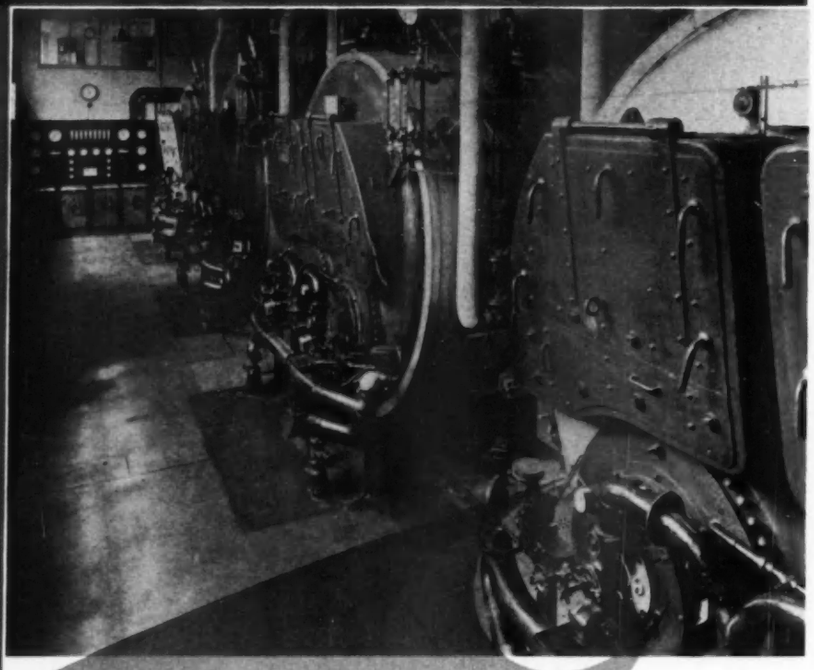

Photos by courtesy of Queen Mary's (Roehampton) Hospital. Boiler plant includes four Marshall Three-pass Economic boilers each fired with two Rotavac No. 3 WSF Burners

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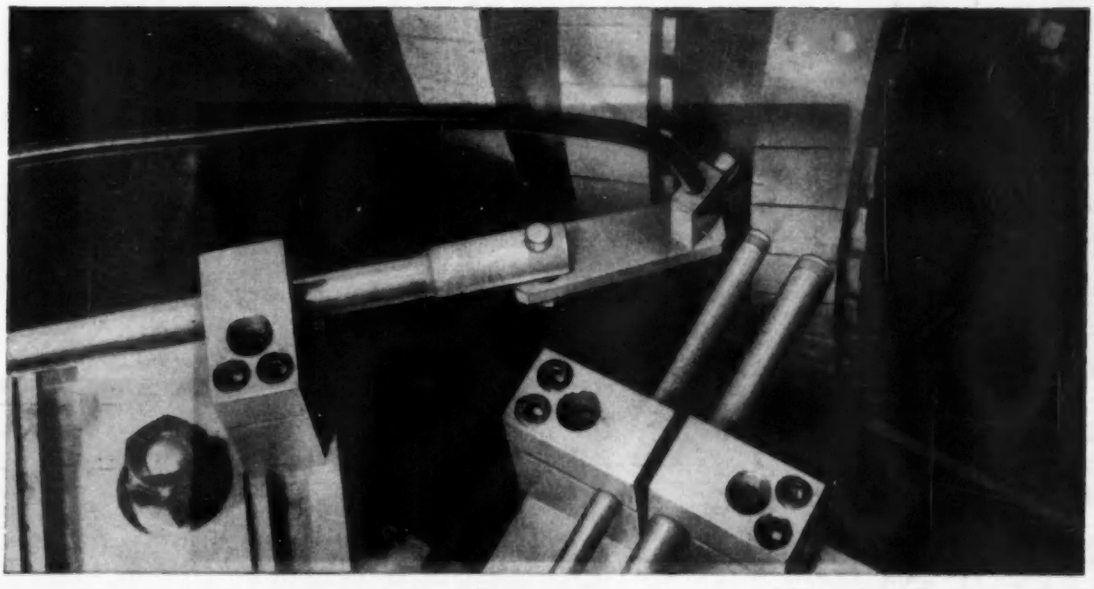

Three measuring probes in position before the turbine was set in motion

The following is drawn from a report by Bristol Siddeley Engines Ltd., on the use of WAYNE KERR Electronic Measuring Instruments:

"Development work in the field of gas turbine engineering frequently involves measurement of the degree of distortion occurring in compressor and turbine rotor assemblies at high rotational speeds. The observations required may be the straightforward diametral growth of simple discs or more complicated axial deflections caused by system asymmetry.

"Measurements of this type must be performed using a non-contacting device, the accuracy of which is unaffected by the peripheral speed of the specimen. Although optical devices have been employed, the capacitance probe system illustrated has proved to be the best solution to the problem from the points of view both of the accuracy of measurement and the range of observations which can be attempted.

"Photograph No. 1 (reproduction above) shows a typical rig assembly in which the specimen is an axial compressor rotor. For rig purposes the blades have been replaced by dummy blade weights of equivalent mass to the true blading, and the periphery has been ground to provide a cylindrical reference surface. The two guard ring probes in use on the dummy blades at the left end of the compressor rotor are used to indicate the elastic radial dilation and the degree of tilt occurring at this point.

"The remaining probe, which is fitted with a swivel head, is sensitive to displacements in the axial direction and is measuring the axial movement at the side of the dummy blade weights."

The report then gives details of the equipment's performance, quoting a discrimination better than 0.0002″ at 0.080″. It goes on:

"The general accuracy of measurement of the bare equipment is considerably better than ±1%, but the overall accuracy under rig conditions is influenced by other factors, such as rotor movement in the bearings, and general mechanical and thermal distortion of the rig and probe supports as a whole. It is estimated that in favourable circumstances measurement accuracies are of the order of ±2%."

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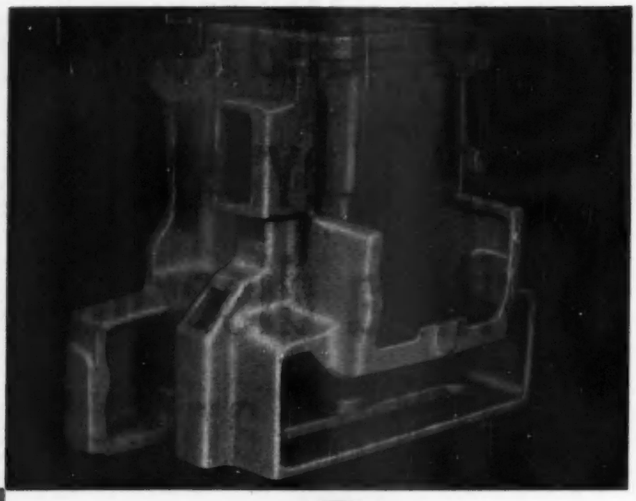

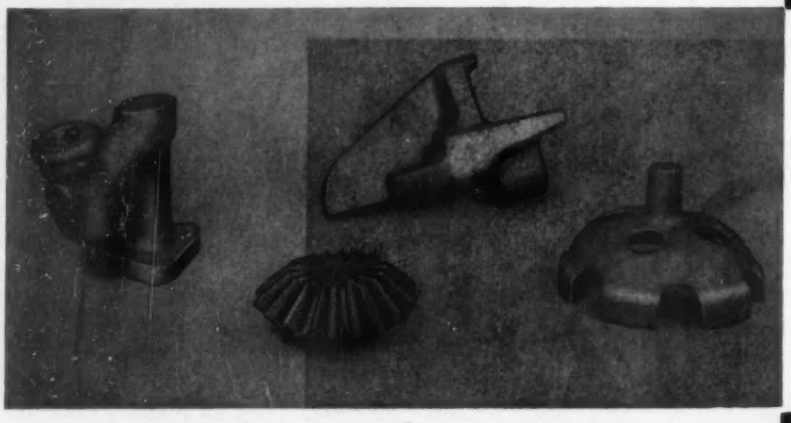

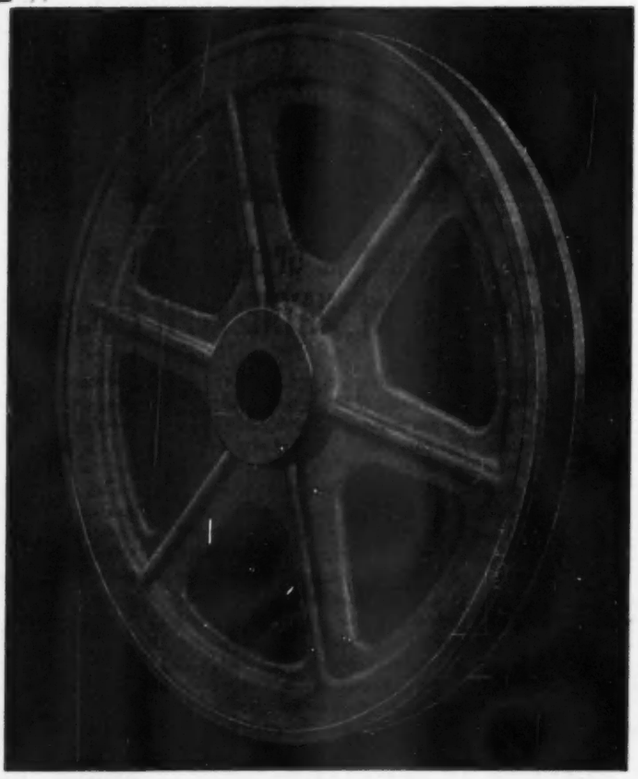

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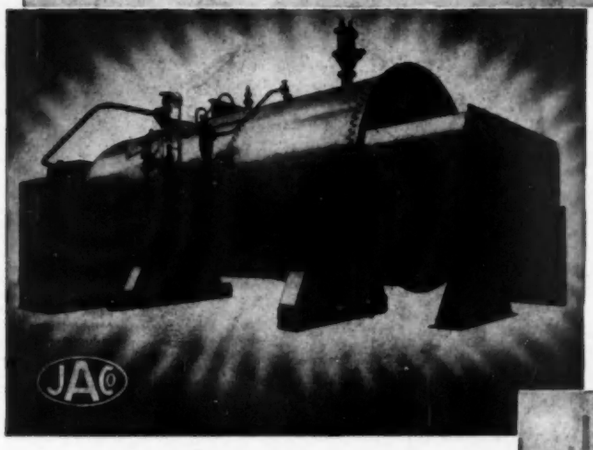
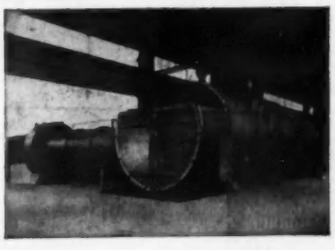
JOSEPH ADAMSON
Waste Heat Boilers





The Joseph Adamson Waste Heat Boiler is designed to make efficient use of the waste gases leaving open-hearth furnaces, reheating furnaces, soaking pits, gas retorts, etc.

The straight-through fire tubes have a high ratio of length to bore, giving about 90% tube efficiency and providing a large area of heating surface in a comparatively small space. Brickwork setting is not required and air infiltration is thus avoided.

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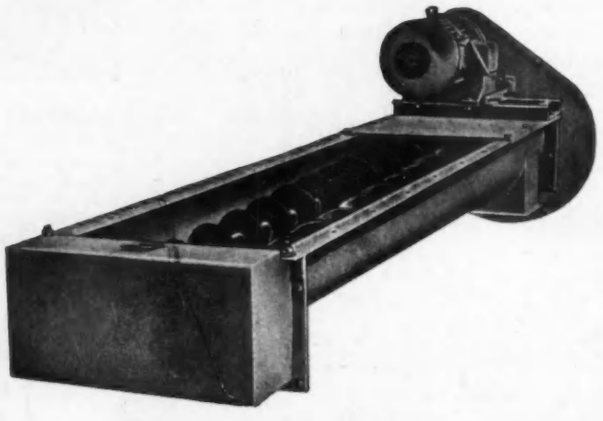

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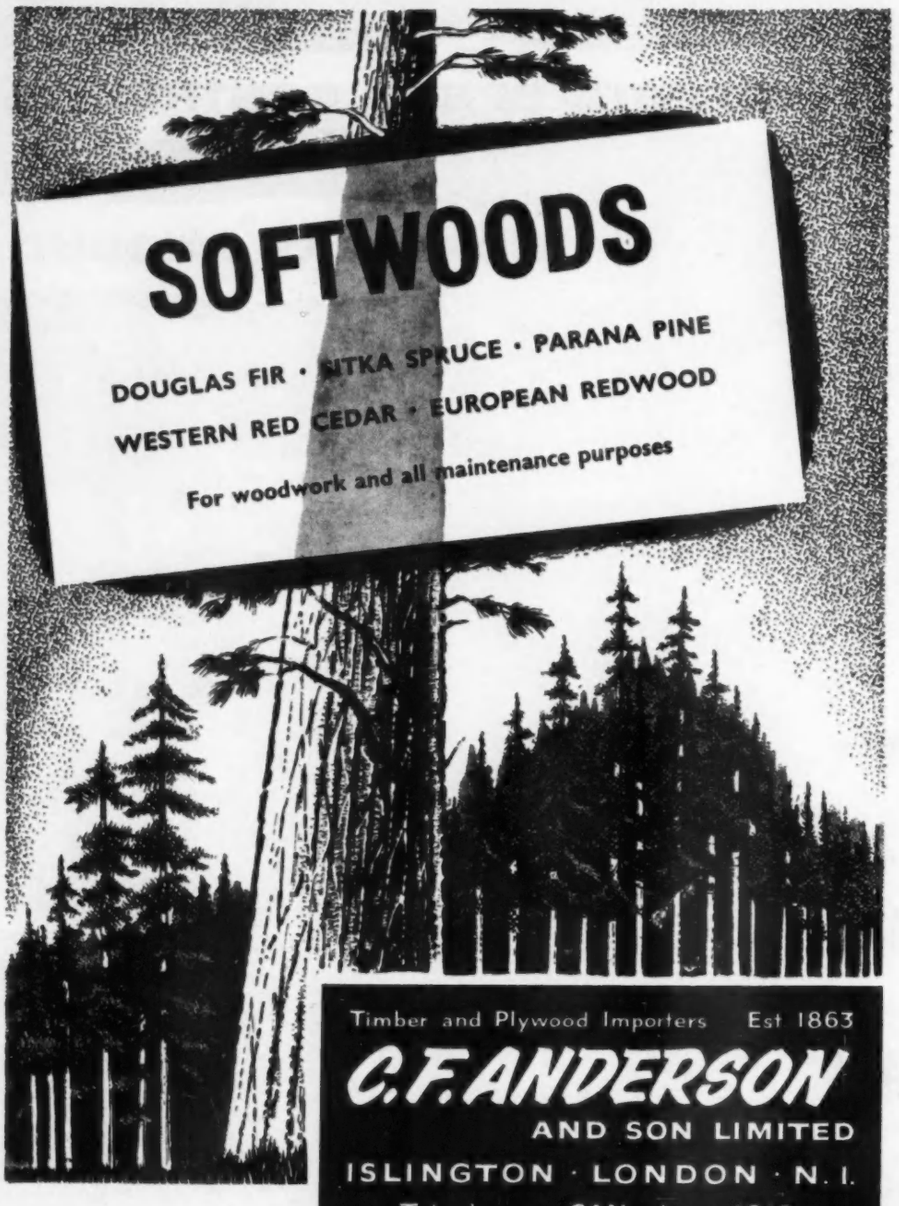
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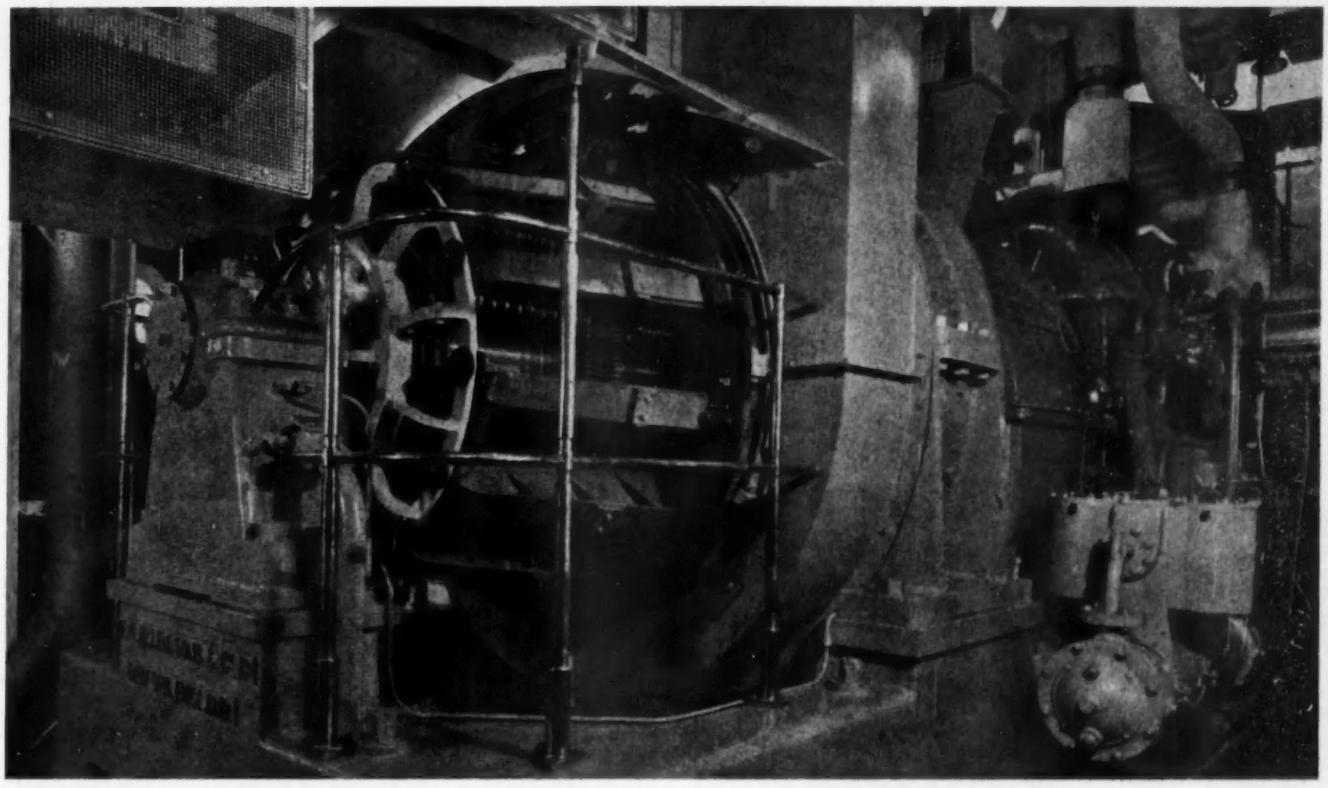

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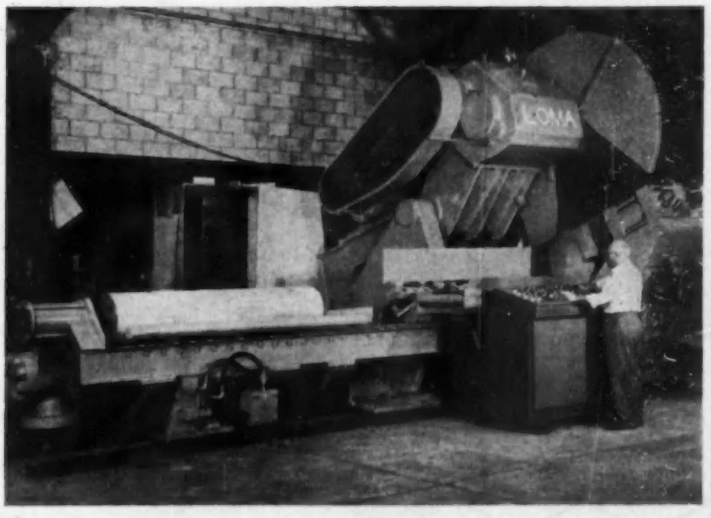

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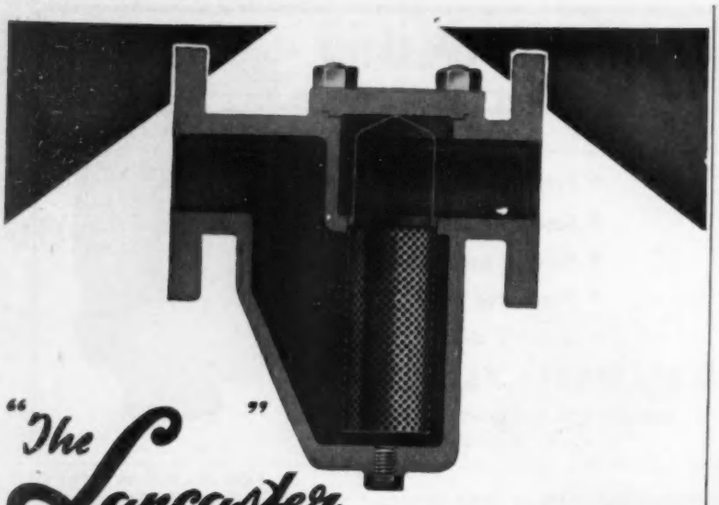

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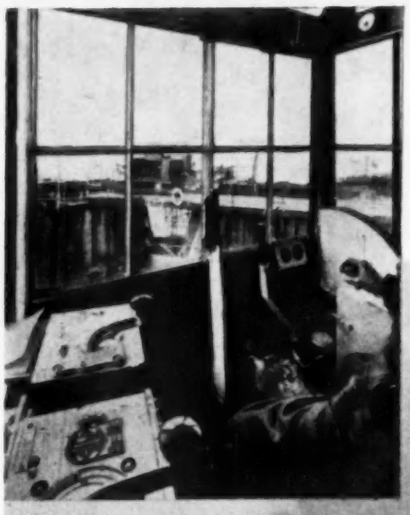
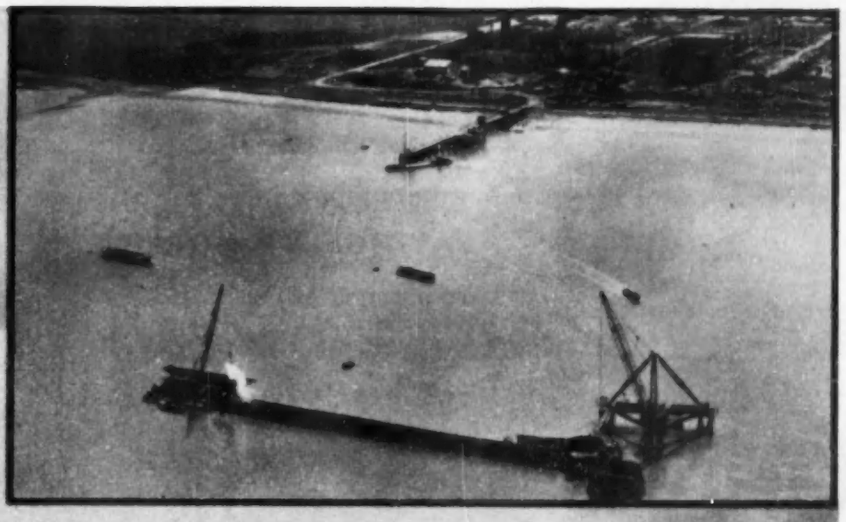
HENDERSON



The operator's cabin, showing the wide field of vision and easily accessible controls.

supply a special crane for BRADWELL

With acknowledgements to Sir Robert McAlpine & Sons



The crane in use during the construction of the water intake.

Henderson, leaders in derrick crane design, supplied this special 15-ton multi-motor crane for the construction of the water intake for the nuclear power station at Bradwell. The 150 ft. jib provides a free working radius of 112 ft. A torque convertor is fitted to the hoisting motion, and automatically gives infinite speed variation according to load handled. Lifting speeds up to 225 ft./min. with a 4-ton load.

JOHN M HENDERSON & COMPANY LIMITED

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INCREASED PRODUCTION
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N·I·F·E·S *National Industrial Fuel Efficiency Service*
71 GROSVENOR STREET LONDON W1
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British Industry's Ally in the Pursuit of Higher Productivity

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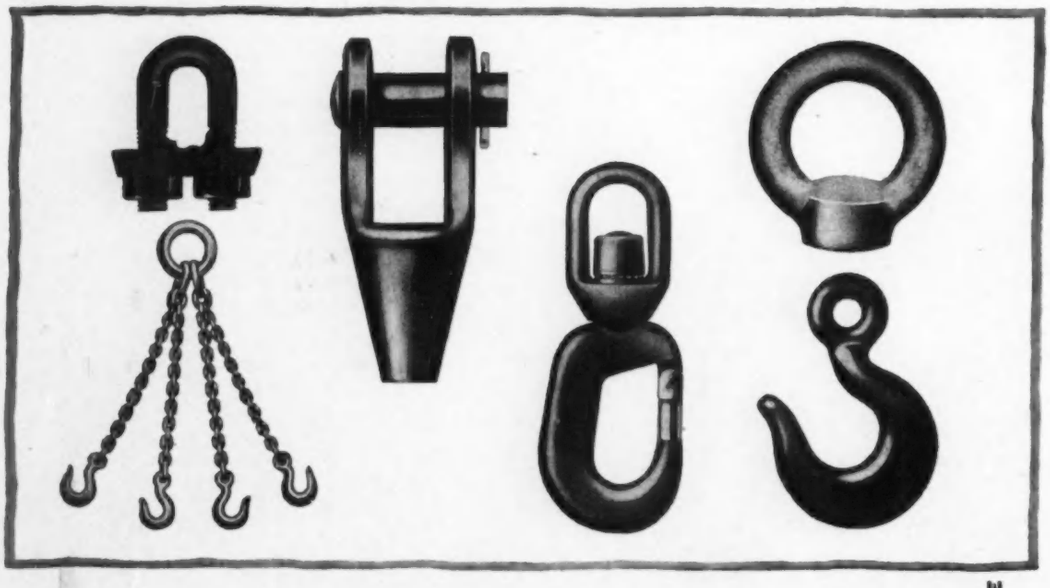

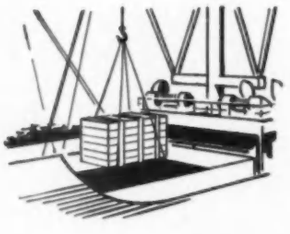

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CHAIN SLINGS · LOAD BINDERS · WIRE GRIPS & SOCKETS

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LIFTING GEAR LTD

TWO WOODS LANE · QUARRY BANK · BRIERLEY HILL · STAFF
Telephone: BRIERLEY HILL 77541-2-3 Telegrams: "LIFTWELL, BRIERLEY HILL

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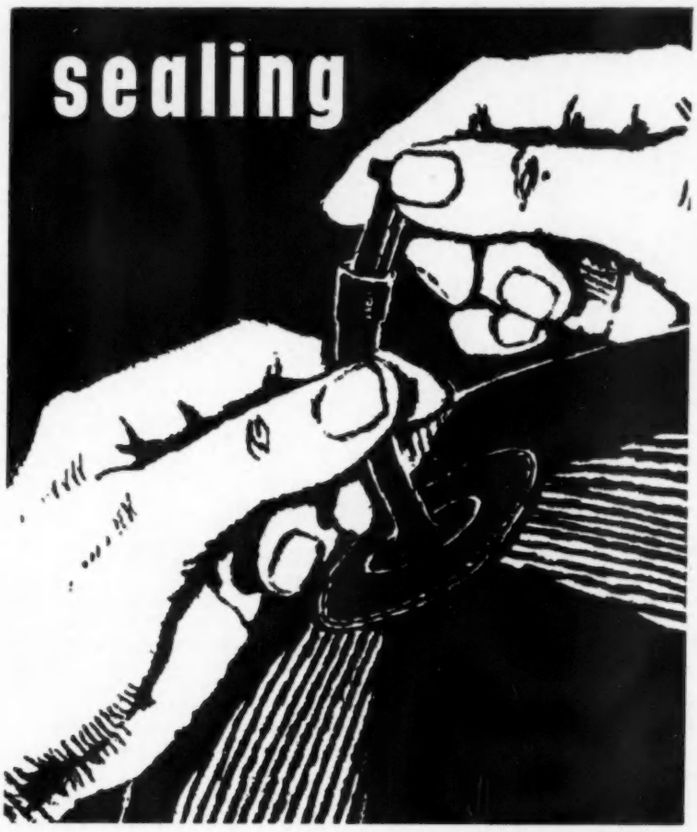

cushioning
damping

Tesamoll is the answer to your problems. In strip or sheet form, it is a self-adhesive urethane foam material with unique features for sealing and anti-vibration. Its inter-connected cellular structure compresses easily with a constant and gentle 'push back' and practically no set. It is rapidly replacing foam rubber and felt, and in many cases gives superior results.

Dust and damp protection. In the field of radio, electronics and television, Tesamoll is widely used to seal cabinets and cases, and to seat cathode tubes. Being electrostatically negative it tends to repel dust and other gas and airborne particles. Milling machine engineers use Tesamoll gaskets to seal powder chambers.

Vibration and shock reduction. Tesamoll is ideal for mounting delicate instruments to eliminate the effect of shock, chatter and vibration, or to compensate for uneven surfaces.

Reduce costs, speed production. The powerful pressure-sensitive adhesive of Tesamoll sticks instantly and firmly to any clean, dry surfaces. Worth an extra pair of hands in many cases, it saves time, is clean to use and eliminates waste.

Made for the job. Tesamoll is specially manufactured for industrial use. The urethane foam is permanently and chemically bonded to the tough P.V.C. support which carries the pressure-sensitive adhesive. The adhesive is protected by an easily removable corrugated P.V.C. covering.

Send for free booklet and samples. Tell us about your problems and we will send you samples of Tesamoll to test, together with a technical booklet giving physical, electrical and chemical characteristics as well as the range of thicknesses, widths and prices. Write today for your copy.

Tesamoll

SEALDRAUGHT LIMITED Tesamoll Division
Chandos House, Buckingham Gate, London, S.W.1. ABBey 3571

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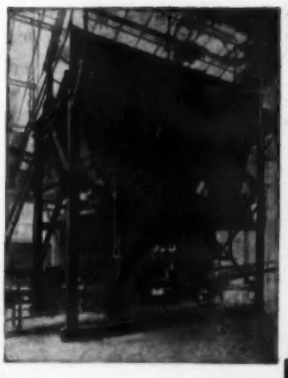
Accurate Handling

. . . more than ever essential in a wide range of industries, from biscuit making to plastics manufacture. Essential for the consistency of products which the quality-conscious manufacturer and the discriminating customer both look for. Essential for avoiding wastage of materials through spoiled batches. Essential for efficient stock control.

More than ever attainable in the same wide range of industries, thanks to the comprehensive skills developed by Simon Handling Engineers Ltd in materials handling and process control. The various techniques which have been evolved for dealing with highly diverse materials, sometimes in combination, are constantly being extended and improved.



ACCURATE HANDLING at the Empire Rubber Company, Dunstable, where a Simon Handling Engineers automatic proportioning system is used to control the weighing and mixing of the ten drugs most commonly used in the manufacture of a wide range of rubber motor-car accessories and other articles.

ACCURATE HANDLING at the Birkenhead works of Fibreglass Ltd., where the weighing and mixing of seven ingredients, controlled automatically from a panel, forms part of a complete plant developed and built by Simon Handling Engineers Ltd for the intake, storage and proportioning of materials.

For accurate handling, fast handling and clean handling see

Simon Handling Engineers Ltd

STOCKPORT, ENGLAND

Telephone GATley 3621 · Telex 66-287 · Telegrams S.H.E.L. Telex Stockport.

HS359

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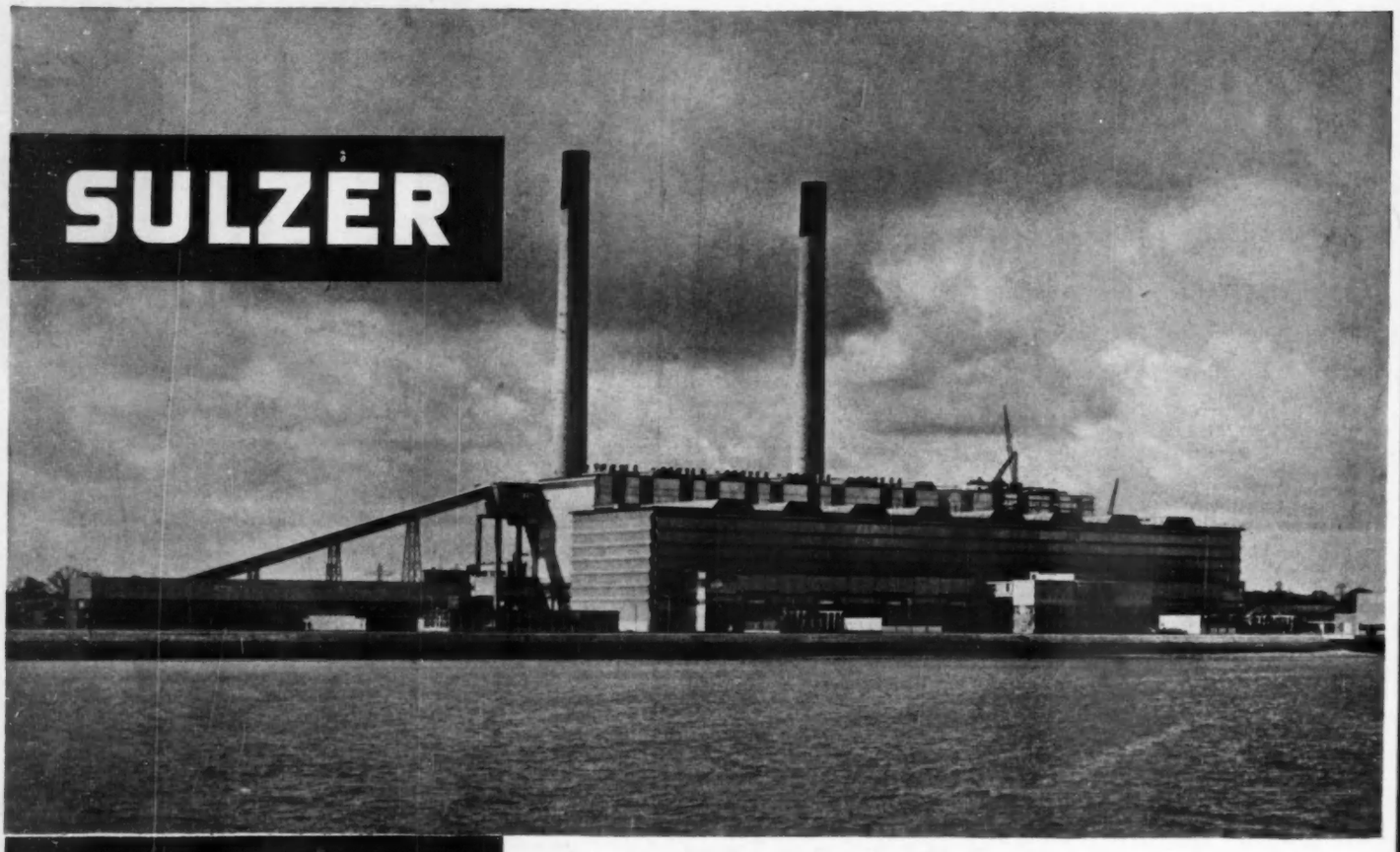
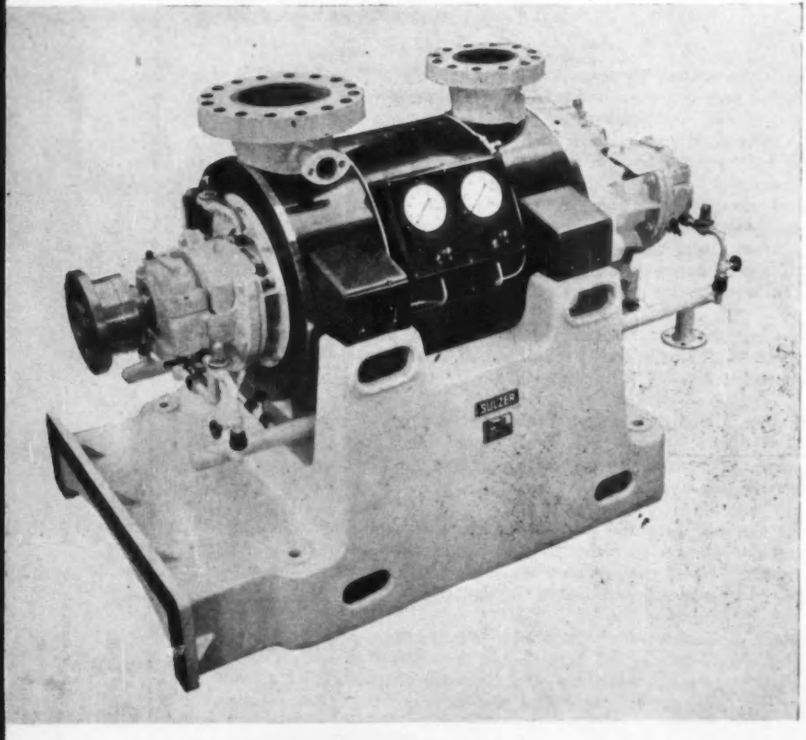


Installed in the Marchwood Power Station for the Central Electricity Generating Board.

One of twelve electrically driven Sulzer Boiler Feed Pumps, each with a capacity of 650,000 lbs per hour, at a pressure of 1,242 lbs p.s.i. and a temperature of 260°F.

Complete range of Boiler Feed Pumps for Nuclear and orthodox Thermal plants including advance class units.



Telephone Museum 7890

SULZER BROS. (LONDON) LTD.,

Incorporating Hathorn Davey & Co. Ltd.

31 Bedford Square, London, W.C.1.

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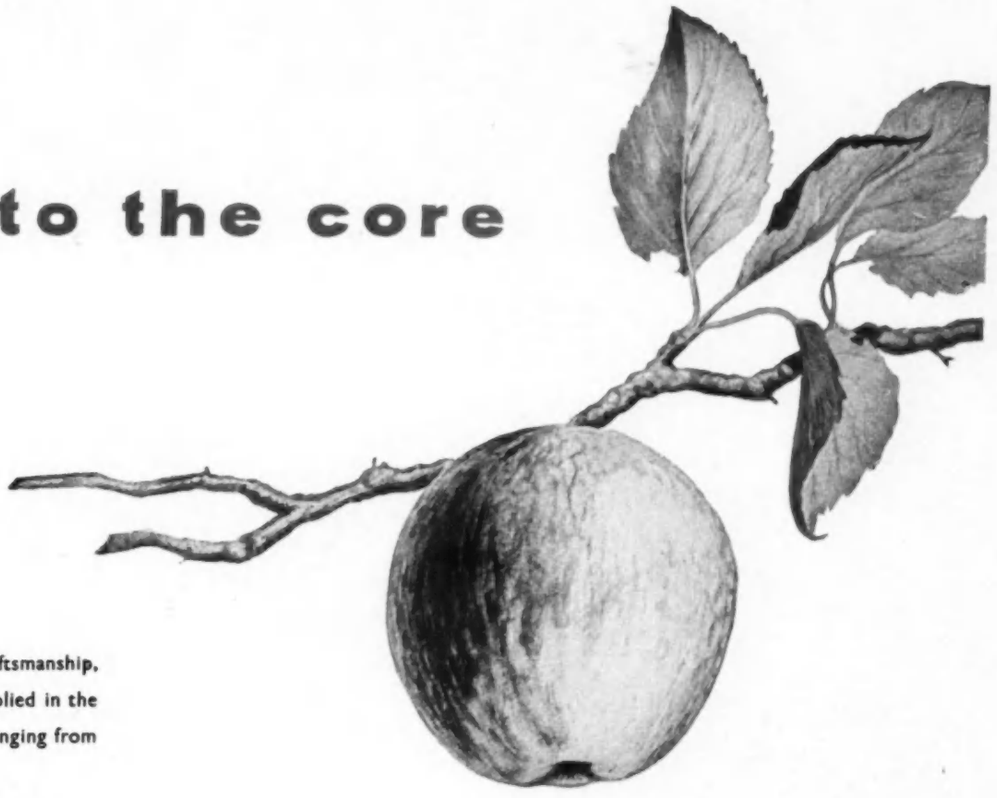
Sound to the core



Modern steel-founding is a blend of craftsmanship, art and technology, all of which are applied in the Osborn foundries to produce castings ranging from a few pounds to several tons in weight.

Castings in carbon and alloy steels are manufactured for many industries including General Engineering, Mining, Quarrying, Oil Refining, Dredging, Chemical and Electrical Engineering. The Company's reputation as steelmakers ensures that only the finest steels are used for these castings, which are sound throughout and of the ultimate standard of quality.

Osborn castings are used in this *Hayward Tyler - Byron Jackson six stage 'Multiplex' pump.* Inset illustrates core used for casting the upper half of casing.

OSBORN

SAMUEL OSBORN & CO., LIMITED
CLYDE STEEL WORKS, SHEFFIELD

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FERRANTI
HIGH VOLTAGE TESTING EQUIPMENT FOR RUSSIA

Ferranti Ltd., are specialists in the design and manufacture of A.C., D.C. and Impulse Testing Equipment for the development of high voltage generating, transmission and distribution plant.

Many Ferranti equipments have been installed in laboratories of research institutes, technical colleges and transformer, cable and switchgear manufacturers throughout the World where they are in continuous use both for routine testing of industrial and domestic electrical appliances, insulating oil, cables, etc. and for development of high voltage electrical power equipment.

The Russian contract includes two D.C. testing equipments (one giving an output of 2,000,000 volts); six A.C. testing equipments (including one with a rating of 3,000 kVA at 1,500,000 volts, and one with a rating of 4,500 kVA at 750,000 volts); one 3,600,000 volt impulse generator and other smaller items.

The largest contract for this type of high voltage testing equipment ever placed with a British manufacturer

FERRANTI

FIRST INTO THE FUTURE

FERRANTI LTD · HOLLINWOOD · LANCS · *Tel:* FAllsworth 2000

London Office: KERN HOUSE · 36 KINGSWAY W.C.2 · *Tel:* TEMple Bar 6636

FT 251/2

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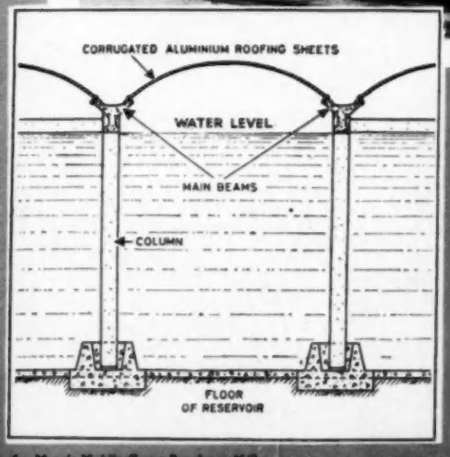
MORRIS CAPS IT ALL



with two M120 Diesel Electric
MOBILE CRANES

The Morris 6 ton mobile cranes illustrated, are erecting the columns and the main beams which will support the aluminium sheet roof of a 16 million gallon concrete lined reservoir now being constructed at Weeton, Lancs., for the Fylde Water Board. Each crane has a 35ft. jib made up of two 15ft. sections and one 5ft. centre section.

The cranes lend themselves admirably to a somewhat unusual situation involving partial dismantling, so that they can be passed through an 8ft. wide culvert leading to the floor of the reservoir basin where they are seen operating.

Although, in this instance, the cranes are shown fitted with strut jibs, the Morris range of mobiles embraces cranes with cantilever jibs, truck and lorry mounted types up to 6 tons capacity in addition to a similar alternative range for loads up to 3 tons.

Please write for Morris Mobile Crane Brochure 46/3

HERBERT MORRIS LTD P.O. Box 7 LOUGHBOROUGH ENGLAND

TELEPHONE: LOUGHBOROUGH 3123

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POWER where YOU want it!

DOWTY hydraulic GEAR MOTORS

- Reversible
- Outputs up to 30 h.p.
- Overall Efficiencies above 80%

DOWTY HYDRAULIC UNITS LIMITED · ASHCHURCH · GLOS.

Member of the Dowty Group

Telephone: Tewkesbury 2271

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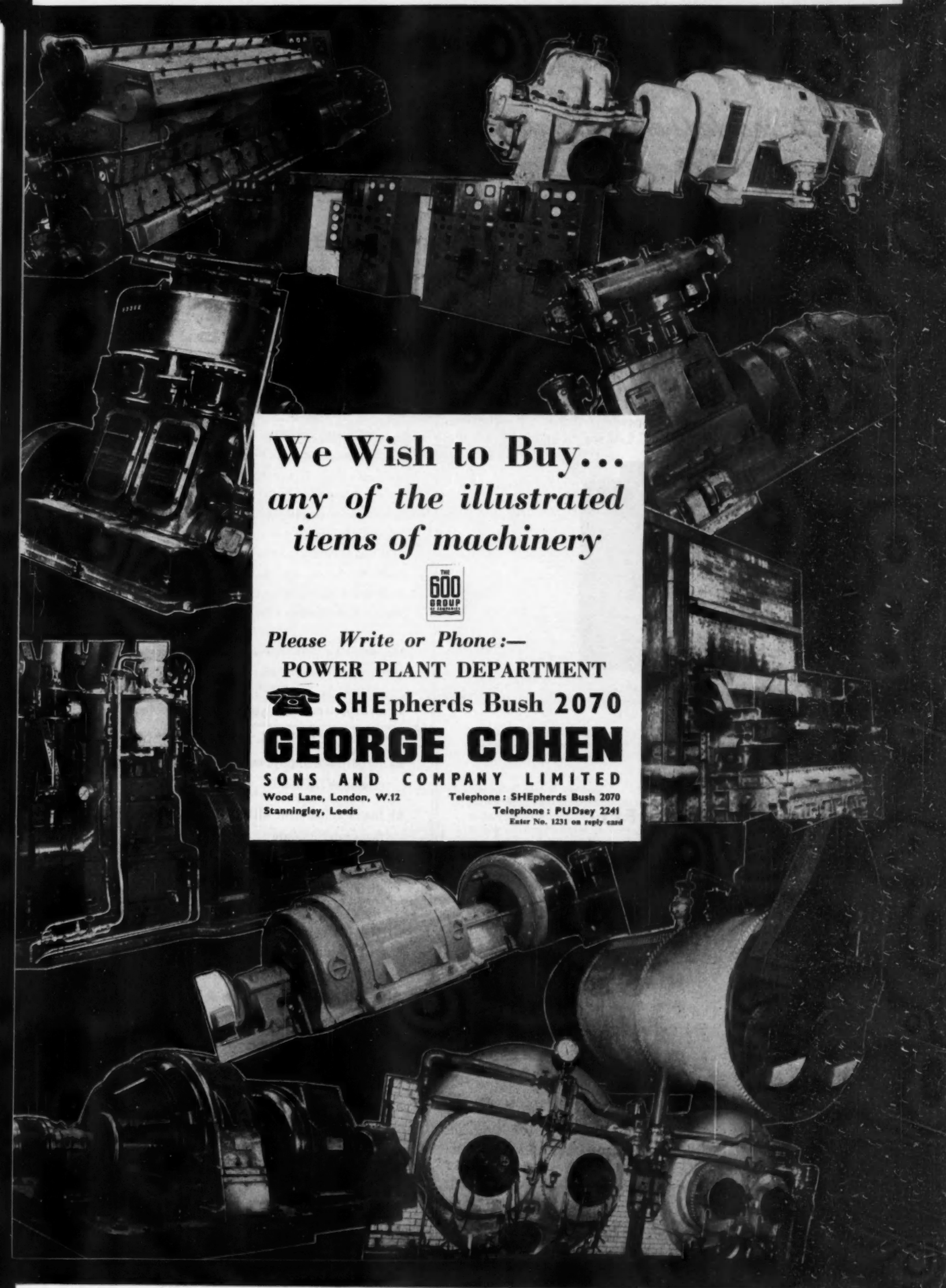

We Wish to Buy...

any of the illustrated items of machinery

THE 600 GROUP OF COMPANIES

Please Write or Phone:—

POWER PLANT DEPARTMENT

SHEpherds Bush 2070

GEORGE COHEN

SONS AND COMPANY LIMITED

Wood Lane, London, W.12 — Telephone: SHEpherds Bush 2070

Stanningley, Leeds — Telephone: PUDsey 2241

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A gearless electrical drive permitting new standards in indexing and control

THE NELSON HETROPOLAR MOTOR provides a true synchronous direct drive allowing you to **lose** the risk of movement from 'gear lash'; to **lose** the need for a gear reduction unit to obtain a speed of 75 rpm at 60 cycles or 62.5 rpm at 50 cycles; to **lose** the need in machine design for space to accommodate such a unit; to **lose** the need for regular maintenance, the Nelson Motor has only one moving part, wear is negligible; to **lose** the need for ancillary control equipment, the motor provides immediate stop/start (full speed in less than half cycle) instantaneous reversal. C.S.A. approved.

you PROFIT from what you LOSE with the

NELSON HETROPOLAR MOTOR

Find out more about this motor or approach us if you're looking for something 'special' in electrical drive.

THE NELSON ENGINEERING CO. LTD.
NELSON, LANCS. Nelson 62545/6/7

Enter No. 1241 on reply card

a positive and traceable return from industrial advertising

On April 1st, 1960 an Oldham Engineering Firm retained us to promote a diversified product the sales of which, during the first six months of availability, had totalled less than £100.

The Company has no permanent representation nor sales agents for this item, yet resultant from our retention it has an expanding order book indicative of a first year's trading well in excess of five figures. Positive enquiries received confirm our findings that the Company can and should achieve within 2/3 years a product turnover of not less than £100,000 annually from these outlets.

The product is a notable technical advance but the successful marketing can be attributed to our fundamental approach which is:

a) an experienced analysis of the sales potential of engineered products

b) statistical and physical market research (relative to economic trends)

c) the establishment within the known market of a favourable climate

d) the origination, production, skilful direction and distribution of 'hard sell' promotion material

Costs of this campaign are proportionate to turnover growth. If you have any doubt as to the return your Company obtains from expenditure on advertising we shall be pleased to discuss your product/service potential

HOUGHTON, GUSCOTT AND PARTNERS LTD
Industrial, Marketing and Publicity Consultants
3 Cateaton Street, Manchester 3 · Bla 8771
Associates in London and the principal capitals of Europe

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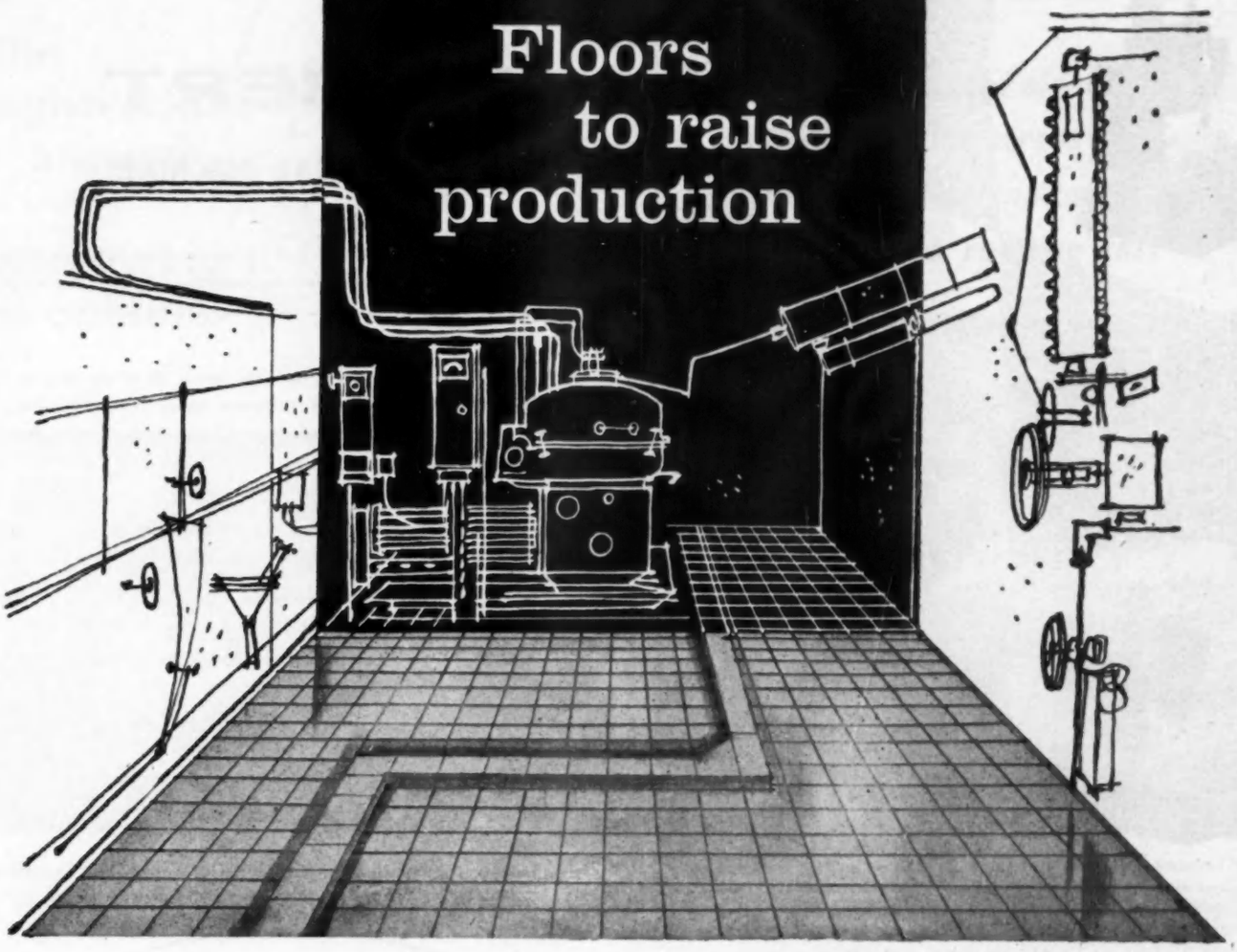
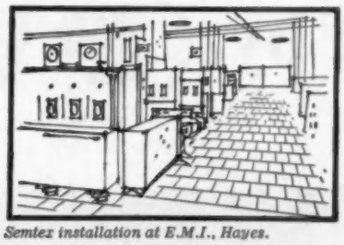
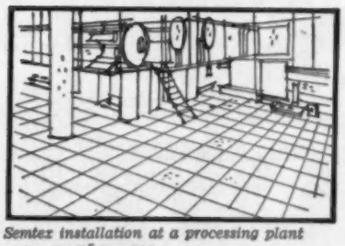
Floors to raise production





Semtex installation at E.M.I., Hayes.



Semtex installation at a processing plant of the Nestlé Co., Ltd.

A Semtex installation at the Ellesmere Port Refinery of the Shell Chemical Company Limited.

The installation of practical, hard-wearing and corrosion resistant floors will save you time and money in putting an end to constant repairs and in improving your annual turnover by uninterrupted production. Semtex, specialists in all types of flooring, will take over your entire flooring operation, designing, transporting and laying materials which proof factory floors, storage bays and machine beds against corrosive agents and mechanical wear. Continued research into the special problems confronting industry has led Semtex to the fore in the manufacture of new materials and in the development of the most comprehensive flooring service in the business.
Get in touch with your consultant now—or write to the address below for further details.

MODERN INDUSTRIAL FLOORING

Semtex Ltd

SEMTEX LTD., 50 BLACKFRIARS ROAD, SALFORD 3, MANCHESTER. Tel: Deansgate 2128

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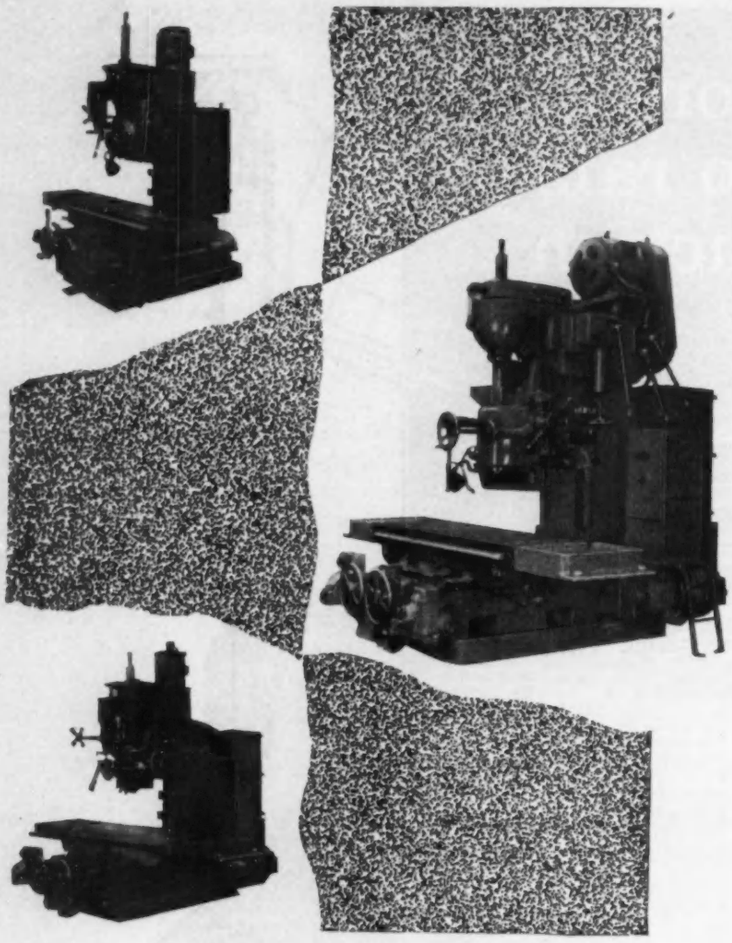

HERBERT

VERTICAL MILLING MACHINES

No. 28A. For heaviest class of work. 32 speeds, 12 to 540 r.p.m. Electronic feed drive, infinitely variable feeds between 0.8in. and 40in. per min. Quick-power traverse to longitudinal and transverse motions. 62in. by 29in. by 30½in.

No. 47V has the power, speeds, feeds and rigidity for milling materials from aluminium to high-tensile steels. Thirty-two speeds, 21 to 1,525 r.p.m.; twenty-four feeds ¾in. to 60in. per min.; quick-power traverse to longitudinal motion. 48in. by 16in. by 23in.

No. 49V. For heavy work requiring large table capacity. 32 speeds, 21 to 1,525 r.p.m. Electronic feed drive, infinitely variable feeds from 0.8in. to 40in. per min. Quick-power traverse to longitudinal and transverse motions. 62in. by 29in. by 28½in.

Available for Early Delivery

ALFRED HERBERT LTD., COVENTRY

AD.427

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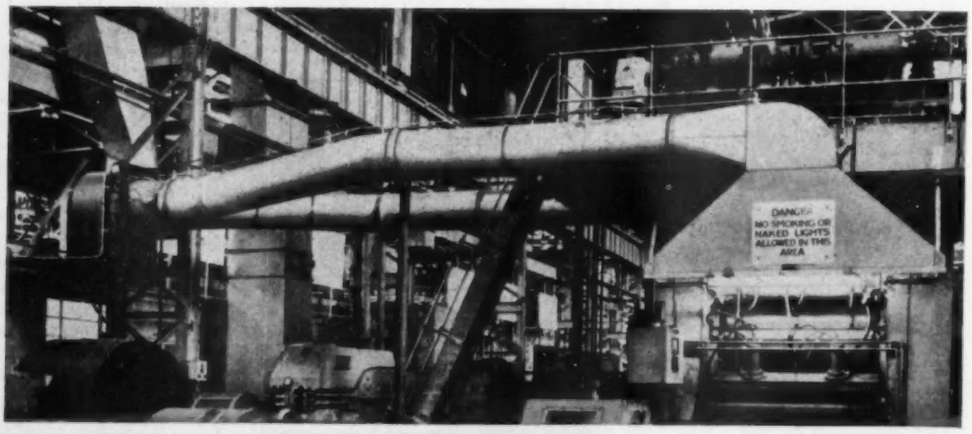
Fume Removal Plant by PVH

Oil fume removal plant from Aluminium Rolling Mill with hoods and ducts in aluminium handling 10,000 c.f.m.

We design, manufacture and install fume removal plants in metal or P.V.C.



PVH

POTTERIES VENTILATING & HEATING CO. LTD.

TUNSTALL STOKE-ON-TRENT *Telephone Stoke-on-Trent 84205/6*

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the lightweight* answer to heavyweight problems

The 'HYDROCON HIGHLANDER' with its unusually simple construction and amazing versatility is the key to higher profits and lower operating costs. On a chassis no larger than a family car and with many exclusive design features, the Hydrocon Highlander is never out of a job on the busy building sites of today. One cab, one operator, full circle slewing. No clutches, no electric motors. Finger-tip controls, permitting 3 motions at once. Jibs up to 56', erected without mechanical assistance. Rapidly lowered outriggers with universal foot pads. Rotary Hydraulic Motors for precision control—full interchangeability—no maintenance. Fast winch speeds—'double safety' brakes—power lowering for precision control. One rope for all jib lengths. Winch parts 90% interchangeable. 5 ton capacity—fully slewing model.

* ROBUSTLY CONSTRUCTED THROUGHOUT.

The Hydrocon Highlander is fully described in colour brochure. Please write for your copy.

HYDROCON HIGHLANDER
FULLY SLEWING MOBILE CRANE

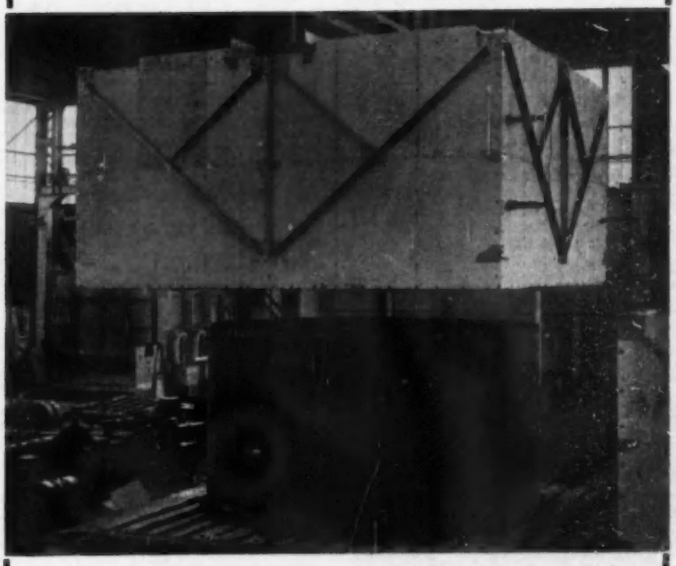
LAMBERT ENGINEERING CO. (GLASGOW) LIMITED
Burnfield Works · Burnfield Road · Giffnock · Renfrewshire · Scotland

Sole distributors in England and Wales: BROWN & TAWSE (PLANT) LTD., Ambrose Street, West Gorton, Manchester, 12. *Grams: Hexameter Manchester 12. Tel: Manchester East 2231 (5 lines).* Also at Birmingham and London. *Scottish agents:* J. A. STEWART (PLANT) LTD., Milnbank Works, Townmill Road, Glasgow, E.1. *Grams: Jasplant, Glasgow. Tel: Bridgeton 4461*

Enter No. 1271 on reply card

STRESS RELIEVING & PRE-HEAT PROBLEMS ANSWERED — No. 1

Simply constructed electric furnaces provide stress relieving facilities for low capital outlay and at off-peak running cost

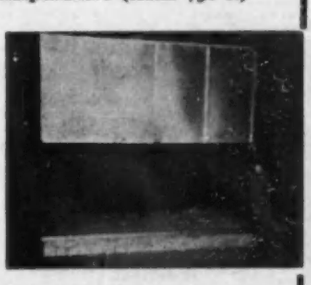


23'×23'×11' *Top Hat Furnace (Courtesy—International Combustion Ltd.)*

Consider the advantages of these furnaces which can be constructed by your own staff employing COOPER Top Hat Principle. Comprising a firebrick base containing COOPER Coiled Elements, a simple framework lined with mineral wool and sheeted on outside, these furnaces allow :—

- ★ **Off-Peak stress relieving at £1 PER TON**
- ★ **Operate off existing mains . . . no extra transformer capacity required**
- ★ **Low capital cost (10/- to 30/- per cubic ft. range) depending on size**
- ★ **Can be built in extremely short time**
- ★ **Height can be increased by jacking up and closing gap with mineral wool mattresses**
- ★ **Extremely even operating temperature (max. 750°c.)**

Remember—It is difficult to judge what size furnace you may eventually need. Subsequent modification to the size of a COOPER Top Hat Furnace may be readily carried out



14'×12'×5' *Furnace (Courtesy: Wm. Neill & Son Ltd.)*

For solutions to stress relieving and preheat problems consult :-

COOPER ELECTROHEAT LIMITED
164 LORD ST · SOUTHPORT · LANCS · SOUTHPORT 2062
Illustrated handbook on request

HGP/cs1

Enter No. 1272 on reply card

CLASSIFIED ADVERTISEMENTS

PUBLIC APPOINTMENTS · SITUATIONS VACANT · TENDERS · EDUCATIONAL · BUSINESSES and PREMISES · BUSINESS OPPORTUNITIES PATENTS · MISCELLANEOUS · AGENCIES · DIRECTORS · PARTNERSHIPS

Lineage Rate. 4/6 per line of approximately 6 words. Minimum 18/-. **Inch Rate.** 54/- per single column inch and pro rata. 12 lines to 1 inch.

There are reduced rates (i.e., not on a pro rata basis) for advertisements of ¼-page (12 column inches) and upwards, e.g., ¼-page £29 10s. ½-page £54. Full page £100.

FOR SALE · MACHINERY, etc., WANTED · AUCTION SALES · SITUATIONS WANTED · SUB-CONTRACTING · DESIGN SERVICES · FOR HIRE

Lineage Rate. 4/- per line of approximately 6 words. Minimum 16/-. **Inch Rate.** 48/- per single column inch and pro rata. 12 lines to 1 inch.

There are reduced rates (i.e., not on a pro rata basis) for advertisements of ¼-page (12 column inches) and upwards, e.g., ¼-page £25 10s. ½-page £48. Full page £90.

Run-On and Semi-Displayed Styles. Both these styles are available for single column width advertisements of any depth up to 12 inches.

Displayed and Illustrated Styles. The minimum size for a Displayed advertisement is 3 inches single column, for an illustrated advertisement it is a ¼-page (12 column inches). Thereafter the sizes for both progress in steps 3 inches deep across 1, 2, 3 or 4 columns.

Use of Box Number. 2/- which includes forwarding of replies.

Copy Dates. Tuesday for publication on Friday of the same week. If proofs are wanted, copy is required on Thursday for publication on Friday of the following week.

***Advertisements for publication should be addressed to:*—Classified Advertisement Dept., "THE ENGINEER," 28 Essex Street, Strand, London, W.C.2**

Urgent advertisements may be telephoned to CENtral 6565.

PUBLIC APPOINTMENTS

UNITED NATIONS SPECIAL FUND

UNIVERSITY COLLEGE OF THE WEST INDIES, TRINIDAD

APPOINTMENTS

Applications are invited by UNESCO for the following posts at the University College of the West Indies, Trinidad, for the new Faculty of Engineering :

(1) PROFESSOR OF ELECTRICAL ENGINEERING. Higher degree or diploma in Electrical Engineering. Experience of teaching at university or comparable level. Interest in power engineering an advantage. Responsible for administration and organisation of department ; also teaching duties for degree course.

(2) SENIOR LECTURER IN MATHEMATICS. University honours degree in Mathematics. Experience in teaching mathematics to engineers desirable ; will be required to take part in teaching students up to final year of B.Sc. course.

(3) SENIOR LECTURER IN MECHANICAL ENGINEERING. Higher degree or diploma in Mechanical Engineering. Experience of teaching at University or comparable level. Knowledge of applied thermodynamics and heat engines desirable.

The University College is in Special Relationship to the University of London and the degrees awarded are those of London.

Two year renewable appointments. Basic salaries, Professor £2607 p.a., Senior Lecturers £2143 p.a. Additional allowances range from £673 to £796 for married men, plus £107 per child, and installation allowance. All emoluments tax free.

Write to Ministry of Labour, E.9, Almack House, 26-28, King Street, London, S.W.1, for job descriptions, mentioning BWI 450/448/449. E5907

CITY OF LIVERPOOL EDUCATION COMMITTEE

COLLEGE OF TECHNOLOGY
BYROM STREET, LIVERPOOL, 3

Principal : S. A. J. PARSONS, B.Sc.(Econ.), M.I.Mech.E., M.I.Prod.E., M.B.I.M.

HEAD OF ELECTRICAL ENGINEERING

Applications are invited for the appointment of HEAD of the Department of Electrical Engineering (Grade III). Duties to commence as soon as possible after 1st September, 1960. Salary : £1800 by £50 to £1950 per annum. Applicants must have good teaching, industrial and/or research experience and should possess high academic qualifications.

The person appointed will be expected to develop further the Advanced Courses and Post-Graduate Courses and to encourage research. Work will begin shortly on a building which includes completely new accommodation, laboratories and workshops for the department.

Further particulars and application form (returnable by 28th September, 1960) from H. S. Magnay, M.A., Director of Education, 14, Sir Thomas Street, Liverpool, 1.

THOMAS ALKER,
Town Clerk and the Clerk to the Local Education Authority.

(J.6379) E5901

LONDON COUNTY COUNCIL

HACKNEY TECHNICAL COLLEGE

PRINCIPAL

Applications invited for post of PRINCIPAL of Hackney Technical College, Dalston Lane, E.8, to commence duty in January, 1961, if possible.

Candidates should be graduates or hold an equivalent qualification. Teaching, administrative and industrial experience essential.

The College has departments of (i) Mechanical and Instrument Engineering with Building Trades, and (ii) Electrical Engineering with Chemistry.

Salary scale : £2075 by £75 to £2275, plus London allowance (£38 or £51).

Application forms and further particulars from Education Officer (FE3a/E/2066/9), County Hall, London, S.E.1, to be returned by 23rd September. E5845

PUBLIC APPOINTMENTS

NATIONAL INSTITUTE FOR RESEARCH IN DAIRYING

UNIVERSITY OF READING

SENIOR TESTING OFFICER

A SENIOR TESTING OFFICER is required to take charge of a section in the Engineering Department. The work of this section is mainly concerned with the performance testing of dairy machinery and equipment but also includes scientific and technological experimentation in this field. The present staff includes four Testing Officers, and the laboratories are well equipped for the work involved.

Candidates should have an honours engineering degree with substantial postgraduate experience. Knowledge of the dairy industry would be an advantage but is not essential. Salary £1600 p.a. in scale rising to £2325, with F.S.S.U. superannuation benefits.

Applications, including full details of age, education and experience should be sent to the Secretary, N.I.R.D., Shinfield, Berks, quoting reference 60/14. E5857

UNIVERSITY OF NOTTINGHAM

LECTURESHIP IN CHEMICAL ENGINEERING

Applications are invited for a LECTURESHIP IN CHEMICAL ENGINEERING. Candidates should have an honours degree in Chemical Engineering or corporate membership of the Institution of Chemical Engineers, with experience in research and in the operation and supervision of full-scale chemical plant. Salary scale £1050 to £1475 (efficiency bar) to £1850. Conditions of appointment and form of application, which should be returned as soon as possible, from the Registrar. E5846

ENGINEERING CADETSHIPS IN THE CIVIL SERVICE

A number of ENGINEERING CADETSHIPS are being offered in various Government Departments to men and women under 26 on 1st October, 1960 who have a degree or Diploma in Technology in engineering or physics, preferably with at least second class honours. Exceptional applicants who have served a student apprenticeship or similar course, and who have passed examinations necessary to meet the academic requirements for graduate membership of the professional engineering institutions will be considered. Selection will be by interview.

Successful candidates will be given a comprehensive course of engineering training lasting up to three years and designed to supply the basis of practical experience essential to a professional engineering career. Cadets who satisfactorily complete the course (and obtain graduate membership of the appropriate professional institution) will be appointed to the basic grade of professional engineer in the Civil Service. Promotion to the main grade of professional engineer may be expected after two to six years in the basic grade. Further promotion prospects are good. Employment will be in a pensionable capacity from the outset.

The salary (national scale) during training is £710 (1st year), £740 (2nd year), £770 (3rd year). Basic grade engineers receive from £725 (at age 24) to £1095 (at 34) rising to £1260 (scale under review), and main grade engineers from £1285 to £1730.

For further particulars and an application form, write to Civil Service Commission, 17, North Audley Street, London, W.1. quoting S/565/60. Completed application forms should be received by 30th September, 1960. E5876

CITY OF BRADFORD

ENGINEERING ASSISTANTS

Applications are invited for the above superannuable posts in the City Engineer and Surveyor's Department on Grades A.P.T. I, II, and Special.

Applicants should be suitably qualified and have had experience in Municipal and/or Civil Engineering.

Application forms obtainable from the City Engineer and Surveyor, Town Hall, Bradford, 1, with three testimonials, must be received by the undersigned by 30th September, 1960.

HENRY PATTEN,
Town Clerk.

E5906

PUBLIC APPOINTMENTS

CENTRAL ELECTRICITY GENERATING BOARD

NORTH EASTERN & YORKSHIRE REGION

RESEARCH MECHANICAL ENGINEER

An ASSISTANT MECHANICAL ENGINEER is required for the Regional Research and Development Department with Headquarters at Skelton Grange " B " Power Station Leeds.

The Engineer appointed will be required to work on several interesting investigations which are at present under review and which include turbine bearing studies, the dynamic response of steam boiler controls condenser problems, coal handling and others dealing in turbines and associated Power Station equipment.

The research field is extremely wide so that specialisation is not required. The successful candidate will be expected to co-operate with other sections of the Department dealing with Physics, Metallurgy, Electrical Engineering and Chemistry.

Applicants should have a good honours degree in Mechanical Engineering and at least two years postgraduate experience. Industrial experience in Research or Design would be an added advantage. Previous experience of Power Station Engineering is not a necessary qualification.

The salary scale for this appointment would be within the range of £1285 to £1720 per annum) Grade 5 or 6, BX, Schedule " B " of the National Joint Board Agreement.

There are good promotion prospects within the Research Organisation of the Generating Board.

Forms of application may be obtained from any office of the Board or from the Assistant Regional Secretary (Personnel), Central Electricity Generating Board, North Eastern and Yorkshire Region, 1 Whitehall Road, Leeds 1, to whom they should be returned to arrive not later than the 1st October, 1960. E5885

CHESHIRE RIVER BOARD

BIRKET AND FENDER IMPROVEMENT SCHEME

ASSISTANT RESIDENT ENGINEER

Applications are invited for the temporary appointment of an ASSISTANT RESIDENT ENGINEER on the above scheme. The Works include the construction of a flood relief Pumping Station in a reclaimed portion of the Morpeth Branch Dock, Birkenhead, diversionary works to the Great Culvert, a discharge culvert constructed in tunnel in the dock wall and the erection of pumping plant.

The Assistant Resident Engineer will be required to supervise underwater work carried out by divers and will be required to pass a medical examination for diving up to a maximum depth in water of 40-ft.

Salary £1200 per annum for the duration of the appointment which is expected to be about 18 months, commencing December 1960.

Conditions of Service as Parts, 2, 4 and 5 only of the Scheme of Conditions of Service issued by the National Joint Council for Local Authorities, Administrative, Professional Technical and Clerical Staffs.

Applications endorsed "Assistant Resident Engineer " giving full particulars of age, qualifications, experience and also the names of two persons to whom reference can be made should reach the undersigned not later than 3rd October, 1960.

SANDFORD FAWCETT & PARTNERS,
53 Victoria Street, Consulting Civil Engineers.
Westminster, S.W.1. E5883

MINISTRY OF AVIATION

TECHNICIAN

LONDON

Ministry of Aviation requires TECHNICIAN at London to assist in compilation of glossaries of item names for mechanical components using the NATO supply classification system. Qualifications : Recognised engineering apprenticeship. O.N.C., City and Guilds Final Certificates or equivalent. Knowledge of domestic and NATO cataloguing procedure is desirable. Salary : £875 (age 28) to £975. Application forms from Manager (P.E.2830), Ministry of Labour, Professional and Executive Register, Atlantic House, Farringdon Street, London, E.C.4. E5910

PUBLIC APPOINTMENTS

ADMIRALTY

ROYAL NAVAL SCIENTIFIC SERVICE

SENIOR SCIENTIFIC OFFICERS AND SCIENTIFIC OFFICERS

Royal Naval Scientific Service require SENIOR SCIENTIFIC OFFICERS AND SCIENTIFIC OFFICERS in establishments in following locations: London Area, Haslemere, Baldock, Poole, Cheltenham, Portland, Portsmouth.

Applications invited from graduates and post-graduate research workers with the following interests :

PHYSICS (classical, mathematical and electronic) ; ELECTRICAL ENGINEERING (electronic, telecommunications and radio) ; MATHEMATICS (pure and applied) ; HYDRODYNAMICS, MECHANICAL ENGINEERING (including servo-mechanisms, gyroscopes and welding development) ; CHEMISTRY (ceramics with solid state properties).

Candidates must normally be natural born British subjects of natural born British parents, with First or Second Class Honours Degrees or equivalent qualifications. S.S.Os must have had three years' post-graduate experience and be not less than 26 years of age. Salaries (men) S.S.O. £1330 to £1640; S.O. £730 to £1205 (London), somewhat lower in provinces. Appointments unestablished (with F.S.S.U. benefits), but opportunities may occur for those between ages of 21 and 32 to compete for established posts. Forms from Ministry of Labour, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting Order No. A.359/OA. E5754

STAFFORDSHIRE POTTERIES WATER BOARD

APPOINTMENT OF ASSISTANT IN DISTRIBUTION DEPARTMENT

Applications are invited for the position of ASSISTANT IN THE DISTRIBUTION DEPARTMENT, Grade A.P.T. III (£880 to £1065 p.a.).

Applicants should be neat and expeditious draughtsmen with surveying experience, and have had experience in a Water Undertaking on distribution work.

Housing accommodation in a very pleasant residential area is now available at a reasonable rental, and removal expenses will be paid.

The appointment is subject to the provisions of the National Scheme of Conditions of Service ; to the provisions of the Local Government Superannuation Act, to termination by one month's notice on either side ; and to the successful candidate passing a medical examination.

Applications, stating age, full details of training, qualifications, present and previous appointments, details of experience, together with copies of two recent testimonials, or the names of two persons to whom reference can be made, should be forwarded to the undersigned not later than Friday, 23rd September, 1960.

C. V. BROWN, M.I.C.E.,
M.I.Mech.E., M.I.W.E.,
Engineer & Manager and
Clerk to the Board. E5904

Albion Street,
Hanley,
Stoke-on-Trent.

CITY OF SHEFFIELD

APPOINTMENT OF DEPUTY CITY ENGINEER AND SURVEYOR AND DEPUTY TOWN PLANNING OFFICER

Applications are invited for the whole-time appointment of DEPUTY CITY ENGINEER AND SURVEYOR AND DEPUTY TOWN PLANNING OFFICER at a salary of £2133 6s. 8d. per annum, rising by annual increments of £90 to a maximum of £2403 6s. 8d. per annum (i.e. two-thirds of salary scale of Chief Officer).

Applicants must have had extensive experience, in a responsible capacity, of municipal engineering and town planning, and must hold appropriate professional qualifications.

The appointment will be subject to a medical examination, superannuation, three months' notice on either side, and the usual Conditions of Service.

Applications, which must be made on the official form obtainable from me upon request, must reach me on or before Monday, the 26th September, 1960.

Canvassing, whether direct or indirect, is prohibited and will be a disqualification.

JOHN HEYS,
Town Clerk.

Town Hall,
Sheffield. E5853

PUBLIC APPOINTMENTS

GOVERNMENT OF UGANDA

FACTORIES INSPECTOR (ELECTRICAL)

FACTORIES INSPECTOR (ELECTRICAL), male, aged 25-35, required to advise the Chief Factories Inspector and Factories Inspectors on Electrical Safety in Factories and other industrial places, and to inspect Factories, &c., for enforcement of safety rules in electrical matters. Degree in Electrical Engineering or equivalent (e.g. Graduate Membership of Institute of Electrical Engineering and subsequent completion of Recognised Graduate Apprenticeship in Electrical Engineering) essential. Experience of the investigation and prevention of Electrical accidents and experience of United Kingdom Electricity Regulations made under the Factories Acts desirable. Post permanent and pensionable or on contract/resettlement grant terms if preferred. Salary at appropriate point in scale £939 to £1863 inclusive. Quarters at low rental. Free passages and medical attendance. Education allowance (in respect of children educated in secondary schools outside Uganda). Low income tax. Generous home leave. Further particulars and application forms from Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD 132/9/02/D4. Candidates should state their full names when applying. E5862

BOROUGH OF SHREWSBURY

WATER DEPARTMENT

APPOINTMENT OF AN ASSISTANT ENGINEER

Applications are invited for the above established appointment within salary A.P.T. Grade II (£765 to £880), according to qualifications and experience.

HOUSING ACCOMMODATION WILL BE PROVIDED IF REQUIRED AND REMOVAL EXPENSES PAID.

The appointment is subject to the N.J.C. Conditions of Service, the Local Government Superannuation Acts, a satisfactory medical examination, and termination by one month's notice on either side.

Applications, stating age, qualifications and details of experience, together with the names of three persons to whom reference may be made, should be submitted to the Water Engineer and Manager, Water Department, Shelton, Shrewsbury so as to be received not later than 16th September, 1960.

S. R. H. LOXTON,
Town Clerk.
Guildhall,
Shrewsbury. E5869

CITY OF BIRMINGHAM SALVAGE DEPARTMENT

APPOINTMENT OF DEPUTY CHIEF ENGINEER

Applications are invited for the post of DEPUTY CHIEF ENGINEER in the above Department at a salary within the range £1220 to £1375.

Candidates must be Corporate Members of the Institution of Mechanical Engineers, and the person appointed will be responsible for the installation and maintenance of the mechanical and electrical plant at the various Refuse Disposal and Salvage Works of the Department.

Full details of the appointment may be obtained from the undersigned, to whom completed applications must be delivered not later than MONDAY, 12th SEPTEMBER, 1960.

ALAN E. BARTON,
General Manager.
Civic Centre,
Broad Street,
Birmingham, 1. E5592

MINISTRY OF AVIATION

INSTRUCTORS

FARNBOROUGH

Ministry of Aviation requires INSTRUCTORS at Farnborough, in inspection techniques applied to armoured and transport vehicles and mechanical equipment. Qualifications : Recognised engineering apprenticeship, O.N.C., City and Guilds Final Certificates or equivalent. Previous experience in teaching and demonstrating an advantage. Capable of conducting courses in one or more of the following subjects : practical measurement, welding inspection, engine testing, material testing, tracked and wheeled vehicle driving and inspection, packaging. Salary: £825 (age 28) to £925. Application forms from Manager (P.E.2832), Ministry of Labour, Professional and Executive Register, Atlantic House, Farringdon Street, London, E.C.4. E5909

NATO COMMON INFRASTRUCTURE SLICE VI VLF TRANSMITTER

(1) Preliminary notice is hereby given that it is intended to invite International Competitive Bids in 1960 for the Design, Provision and Proving of a very-low-frequency radio-telegraph transmitting station, to be constructed on an alreadv determined site in the United Kingdom.

(2) The station is to be suitable for operation at ; (a) signalling speeds of approximately 45 bands when radiating a power of approximately 100kW at frequencies in the neighbourhood of 20 kc/s ; (b) considerably higher signalling speeds when radiating at a somewhat lower power. Amplitude and angle modulation will be required.

(3) Enquiries should be withheld pending the issue of a further notice which will enable contractors to indicate their desire to be invited to bid.

GENERAL POST OFFICE.
London. E5903

PUBLIC APPOINTMENTS

WAR OFFICE

TECHNICIAN

War Office requires TECHNICIAN in London for investigation of technical problems associated with production of armoured fighting vehicles, including special purpose vehicles such as armoured recovery vehicles, bulldozers, bridgelayers, &c., preparation of instructions and schedules ; requests for contract action and progressing of work at contractor's works. Qualifications : Recognised engineering apprenticeship ; sound practical workshop experience in machining and fitting operations on fighting vehicles or similar heavy engineering. Knowledge cost estimating and engineering materials an advantage. Ability to assess production progress at contractor's works essential. O.N.C., City and Guilds Final Certificate or equivalent. Salary : £975 (age 30) to £1115 p.a. Application forms from Manager (P.E.2819), Ministry of Labour, Professional and Executive Register, Atlantic House, Farringdon Street, London, E.C.4. E5877

MINISTRY OF AVIATION

TECHNICIAN

HAREFIELD, MIDDLESEX

Ministry of Aviation requires TECHNICIAN at Harefield, Middlesex, to assist in setting up hydraulic and pneumatic test facilities in the guided weapon section of a laboratory, and in the subsequent testing, critical examination and reporting of hydraulic and pneumatic components and mechanisms. Qualifications : Recognised engineering apprenticeship, O.N.C., City and Guilds Final Certificates or equivalent. Conversant with the principles of hydraulics and pneumatics. Practical experience of the manufacture, testing or inspection of such mechanisms an advantage. Salary : £975 to £1115. Application forms from Manager (P.E.2831), Ministry of Labour, Professional and Executive Register, Atlantic House, Farringdon Street, London, E.C.4. E5908

MANCHESTER CORPORATION WATERWORKS UNDERTAKING

DEPUTY ENGINEER AND MANAGER

Applications are invited for the appointment of DEPUTY ENGINEER AND MANAGER of the Manchester Corporation Waterworks Undertaking. Applicants should be Civil Engineers with administrative experience, preferably having a wide experience of the design and construction of large civil engineering works for water supply.

Commencing salary £2753 per annum, rising by annual increments of £90 to £3023 per annum.

Details of appointment and application forms (returnable by 26th September, 1960) from the Secretary, Waterworks Department, Town Hall Manchester 2. E5758

EAST SURREY WATER COMPANY

ENGINEERING ASSISTANT

The Company requires the services of a qualified CIVIL ENGINEERING ASSISTANT on the permanent staff to assist initially with a £750,000 capital works programme. The Company at present supplies an area of 280 square miles with 15 m.g.d.

Housing accommodation will be provided, if required, and removal expenses paid.

Starting salary will be between £1000 and £1250 per annum, according to experience, with pension rights.

Applications, giving details of age, education, qualifications and experience, should be received by the undersigned by the 26th September, 1960.

G. M. SWALES,
B.Eng., A.M.I.C.E., M.I.W.E.
Chief Engineer.
London Road,
Redhill, Surrey. E5855

TENDERS

INDIA STORE DEPARTMENT

The Officer of the Director General, India Store Department, Government Buildings, Bromyard Avenue, Acton, W.3, invites TENDERS for the following :

(a) PLAIN INTERNAL GRINDING MACHINE, swing over table, 18in., maximum length of hole that can be ground, 10in., maximum/minimum hole diameter equals 9in., ¼in.

(b) HORIZONTAL BORING MACHINE similar to Kearns No. 2 Patent Machine, diameter of spindle 76mm., table size 762 by 1220mm.

(c) ONE DUPLEX MILLING MACHINE, longitudinal travel of table 1219mm, vertical movement of milling head on column 305mm.

(d) HORIZONTAL BORING MACHINE, spindle 5¼in. dia., bed 10ft. by 4ft., height of column from bed 12ft., traverse of spindle 28in.

Specifications, &c., can be obtained from the Co-ordination Branch, India Store Department, Government Building, Bromyard Avenue, Acton, W.3, at a cost of 10 shillings per Tender enquiry and is not refundable. Tenders are to be returned to the above address by Monday, 10th October, 1960. Specimen copy of the above enquiries can be seen at Engineering Branch, I.S.D., under the following references :

(a) 2006/60/SGH/ENG. 3.
(b) 2007/60/SGH/ENG. 3.
(c) 2009/60/SGH/ENG. 3.
d) 2018/60/SGH/ENG. 3. E5842

TENDERS

STAFFORDSHIRE POTTERIES WATER BOARD

TITTESWORTH RESERVOIR SCHEME

CONTRACT NO. 41— 30 INCH DIA. MAIN

The Board invite TENDERS from experienced Civil Engineering and Public Works Contractors for the laying of approximately 7600 lineal yards of 30 inch nominal diameter STEEL BITUMEN-LINED and SHEATHED WATER MAIN with Viking Johnson couplings from Tittesworth Reservoir to Ladderedge Reservoir near Leek in the County of Stafford.

The Forms of Tender, Conditions of Contract, Specification and Bills of Quantities may be obtained from the undersigned on deposit of a cheque for five guineas, which will be returned on receipt of a bona-fide Tender not subsequently withdrawn.

Two separate Tenders are required :

(1) Tender with Variations in wages and materials.

(2) Tender on Fixed Price Basis without variations in wages and materials.

The two Forms of Tender and annexed documents, completed on the alternative bases mentioned above, must be enclosed in the plain envelope provided, endorsed " Tender for 30 inch dia. main—Contract No. 41 " and addressed to the Chairman, Staffordshire Potteries Water Board, c/o Engineer & Manager's Office, Albion Street, Hanley, Stoke-on-Trent, and delivered not later than 12 noon on Monday, 10th October, 1960. The sealed envelope must not bear any name or mark indicating the sender. At the same time copies of the Bill of Quantities, completely priced on each of the alternative bases mentioned above, must be delivered in one separate sealed envelope, similarly addressed, and endorsed " Priced Bills for Contract No. 41," and bearing the Tenderer's name.

Tenders which do not comply with the above requirements will not be considered. The Board do not bind themselves to accept the lowest or any Tender.

C. V. BROWN, M.I.C.E., M.I.MECH.E., M.I.W.E.,
Engineer & Manager and Clerk to the Board.
Albion Street,
Hanley,
Stoke-on-Trent. E5889

MINISTRY OF TRANSPORT

THE DARTFORD TUNNEL

FINISHINGS, VENTILATION BUILDINGS AND SERVICES

The Minister of Transport invites TENDERS from experienced Contractors for the following works, to be comprised in one contract :

(1) Furnishing the Tunnel, about 1560 yards long, with a Concrete Lining, a Reinforced Concrete Road-Deck with Paving and Footways, Wall-Finishings and a Suspended Ceiling.

(2) Furnishing the Open Cut Approaches, each about 210 yards long, with Paved Carriageways, Footways, Precast Concrete Slab Facings and Copings, Suspended Sun-Visors, etc.

(3) Constructing two Ventilation Buildings with Reinforced Concrete Exhaust Shafts and other special features.

(4) Providing and Installing (principally through the engagement of nominated sub-contractors) Equipment for Electricity Distribution, Lighting, Tunnel Services and Pumping.

(5) Ancillary Works, including completion of Access Shafts, Passages and Pump Chambers and the Construction of Access Roads.

Copies of the contract documents may be obtained from the Consulting Engineers, Messrs. Mott, Hay & Anderson, of 9, Iddesleigh House, Caxton Street, Westminster, London, S.W.1, on payment of a deposit of £50 by cheque made payable to the Ministry of Transport. The deposit will be returned if a bona fide Tender is submitted and not subsequently withdrawn.

Tenders should be sent in a plain, sealed, registered envelope marked " TENDER FOR DARTFORD TUNNEL CONTRACT No. 7 " and addressed to the Assistant Secretary, Highways Management and Services Division, Ministry of Transport, 21/37, Hereford Road, London, W.2 to arrive not later than 4 p.m. on Wednesday 19th October, 1960.

The Minister does not bind himself to accept the owest or any Tender.

G. G. D. HILL,
An Assistant Secretary.
E5866

INDIA STORE DEPARTMENT

The Office of the Director General, India Store Department, Government Buildings, Bromyard Avenue, Acton, W.3, invites TENDERS for the following :

(a) HORIZONTAL RIFLING BROACHING MACHINE for Gun Barrels of maximum o.d. 14in., bore dia. 3in. to 4.5in., length of bore 24ft.

(b) DEEPHOLE BORING MACHINE with central drive trunnion spindle chuck mounted on each end to clear 18in. dia. forgings. Front and rear beds each 20ft. long approx.

(c) TAPER BORING MACHINE for boring taper in forgings up to 16in. o.d. and 15ft. length. Sketch of job to be done is available.

Specifications, &c., can be obtained from the Co-ordination Branch, India Store Department, Government Building, Bromyard Avenue, Acton, W.3, at a cost of 10s. per Tender enquiry and is not refundable. Tenders are to be returned to the above address by Monday, the 17th October, 1960.

Specimen copy of the above enquiries can be seen at Engineering Branch, I.S.D., under the following references :

(a) 2011/60/SGH/ENG. 3.
(b) 2015/60/SGH/ENG. 3.
(c) 2016/60/SGH/ENG. 3. E5843

TENDERS

SANDY GULLY PROJECT

JAMAICA

SELECTED TENDER

The Ministry of Development of the Government of Jamaica will shortly be calling for TENDERS on the above scheme. All persons interested should, in the first instance, send their names and addresses to the Permanent Secretary, Ministry of Development, 24 East Race Course, P.O. Box 512, Kingston, Jamaica, to reach him not later than the 17th September, 1960.

A deposit of One Hundred Pounds (£100) will be required for each Tender Document and will only be refunded on receipt of a bona fide Tender.

The Contractor is to arrange finance on a deferred payment basis over a period of seven (7) years.

The scheme includes Bridges, Earth works (in dry and wet areas), and Concrete Channel construction (approximately 6 miles) and will probably exceed One Million Pounds.

Will Contractors please note that only firms with experience in the above fields can be considered. E5792

TRINIDAD AND TOBAGO ELECTRICITY COMMISSION

TENDER

TENDERS are invited for the supply of :
115V, SINGLE-PHASE ELECTRICITY METERS and
230V, SINGLE-PHASE ELECTRICITY METERS.

Specifications may be obtained on writing to the Purchasing Officer, Trinidad and Tobago Electricity Commission, P.O. Box 121, Port-of-Spain, Trinidad, W.I.

Closing date for Tenders is 30th November 1960 and they must be sent in plain, sealed envelope marked " TENDER 89." E5882

HEAVY ELECTRICALS LIMITED, BHOPAL, INDIA

TENDERS NOS. PP/F/MT/60/9 PP/F/MT/60/10, and PP/F/MT/60/11

Heavy Electricals Limited, Bhopal, India invite TENDERS Nos. PP/F/MT/60/9, PP/F/MT/60/10 and PP/F/MT/60/11 for MACHINE TOOLS. Tender Forms and Specifications can be obtained from Heavy Electricals Limited, Crown House, Aldwych, London, W.C.2, on payment of £2 5s., £3 and £2 5s. per set respectively, which is not refundable.

Tenders are to be submitted in quadruplicate as specified in the Tender Forms. The closing date is 25th October, 1960. E5871

EDUCATIONAL

A.M.I.MECH.E., B.SC., City and Guilds, &c. Guarantee Postal Courses for all Exams. and Technical Divisions from Elementary to Degree standard including Automation Techniques. Approximately 95 per cent. successes. 148-page prospectus, free on request.—B.I.E.T. (Dept. 22), 29, Wright's Lane, London W.8. E114 z

UNVERSITY OF LONDON KING'S COLLEGE

TUTORIAL STUDENTSHIP IN CHEMICAL ENGINEERING

The College offers a TUTORIAL STUDENTSHIP in the Department of Chemical Engineering. The value is £425 a year, with free tuition in King's College, from 1st October, 1960. Applicants should have a good degree in Chemical Engineering, or a Post-graduate Diploma, and will be expected to undertake research for a higher degree and to give assistance with classes, limited to six hours a week. Maximum tenure four years.

Particulars and forms from the Registrar, King's College, Strand, W.C.2, whom completed applications should reach not later than September 16th. E5786 z

NATIONAL COLLEGE FOR HEATING, VENTILATING, REFRIGERATION AND FAN ENGINEERING

at

Borough Polytechnic, Borough Road, London, S.E.1.

A course of Eight Lectures

on

TUBULAR HEAT TRANSFER EQUIPMENT

Monday evenings, beginning
24th October, 1960

Application forms and further information from : Fredk. J. Packer, Clerk to the Governors.

E5891 z

Classified Advts. continued on page 130

SITUATIONS VACANT

APPLICANTS ARE ADVISED TO SEND COPIES NOT ORIGINALS OF THEIR TESTIMONIALS UNLESS OTHERWISE REQUESTED.

AN INTERESTING AND WELL-PAID JOB with great possibilities for further development is waiting for a man who can write lucidly about production and mechanical engineering. Although this appointment is based on a research centre, in exceptionally pleasant surroundings in the Midlands, opportunities arise for travel to all parts of Britain and, for the right man, possibly overseas as well. Excellent superannuation scheme.—Send details of career and present salary to BOX No. E5799, "The Engineer." A

ARTHUR GUINNESS SON & CO (PARK ROYAL) LTD., require an ASSISTANT ENGINEER to design and supervise the construction, installation and testing of new plant and to negotiate contracts. The appointment is open to Chartered Mechanical or Chemical Engineers who have had experience in such matters, preferably in the Food Processing and Chemical Industries. Experience of Structural Steelwork, Metallurgy and Mechanical Handling Equipment would be an advantage. Age 30-35. Commencing salary from £1200 to £1600 depending upon qualifications and experience. Annual increments, non-contributory pension, and excellent amenities.—Apply to The Personnel Manager, Park Royal Brewery, London, N.W.10. E5884 A

CHIEF DRAUGHTSMAN

Applications are invited for this Senior Appointment with a well-known Glasgow constructional and engineering company from qualified Engineers who have had previous experience in modern design and practices in constructional platework and ancillary work.

The successful applicant will be between 30 and 40 years of age and have drive and initiative. He will be responsible for the efficient running of the drawing office.

Contributory Pension Scheme.

Applications, giving full details of experience, qualifications and salary, together with copy testimonials, to BOX No. E2987, "The Engineer." A

DEVELOPMENT ENGINEERS AND TECHNICAL ASSISTANTS

are required by the United Kingdom Atomic Energy Authority at Dounreay, Experimental Reactor Establishment, Thurso, Caithness, to work in a group which is engaged on development in all fields of engineering; to assist with the operation of the fast reactor and in developing and carrying out experiments to enable information to be obtained from the reactor.

Applicants should have served a recognised engineering apprenticeship and be corporate members of the Institute of Mechanical Engineers, or have equivalent qualifications. Alternatively, candidates with a degree in mechanical engineering who have served a recognised engineering apprenticeship and who wish to extend their post-graduate experience may be considered for posts as Technical Assistants and trained to take up posts as engineers.

Salaries: Engineers £860 (at age 25) to £1175 (at age 34 or over) to £1340.

Technical Assistants: £655 (at age 22) to £1025.

Contributory superannuation. Staff housing scheme.

Hotel accommodation available.

Send postcard for application form, quoting reference 370/31, to Personnel Manager at above address. E5848 A

ENGINEER, 1st Class M.O.T., A.M.I.Mech.E. Preferably with Engineering Insurance experience as assistant to Chief Engineer of Engineering Insurance Association. Age about 35.—Particulars to: Box ZO 246, Deacons Advertising, 36 Leadenhall Street, E.C.3. E5893 A

ENGINEERS, DRAUGHTSMEN, and all Technical staff, are invited to forward details of qualifications, etc., to Abbatt Technical Division, who will handle and negotiate on their behalf, without charge, any change of employment contemplated. Leading Organisations consult Abbatt, 25, Kensington High Street, W.8. WES. 0768-9. E2993 A

GENERAL DRAUGHTSMAN REQUIRED for small London office for work on projects in Company's seven factories. O.N.C. required. Good prospects.—Write age, salary required, &c., BOX No. E5868, "The Engineer." A

HADFIELDS LTD. require a FUEL TECHNOLOGIST to take charge of the Fuel Section of their Research Department. The section is responsible for ensuring the efficient use of a variety of uels in Steel Works Plant. Qualifications required would be an appropriate Degree or Higher National Certificate, with Fuel Technology experience. Age preferably 20-35 years. This position offers excellent working conditions, including Staff Dining and Welfare facilities on a five-day week basis. Replies, giving details of age, qualifications, experience to date and salary required, should be addressed to the Personnel Manager, Hadfields Ltd., East Hecla Works, Vulcan Road, Sheffield, 9, quoting PL.23447. E5849 A

LIBYA

British Company seek man capable of starting and taking charge of a school to train Libyan nationals as motor mechanics, machine shop operatives and welders for steel fabrication. Applicants should be of mature age, have good previous experience of this type of instruction and, preferably, be able to speak Arabic. Good salary, low income tax, free air passages, furnished accommodation, home leave and non-contributory pension scheme.—Write Box AG/141, c/o 95 Bishopsgate, London, E.C.2.

E5858 A

LIFT ENGINEERS required for the erection and servicing of lifts in Nigeria and Ghana. Wide experience of this work is essential and some knowledge of the more complicated high-speed installation would be an added advantage. Appointments are to be made to the permanent staff, and there are also contract vacancies for periods of 24 months, salary dependent upon experience and terms of engagement, but in the region of £1300 to £1500 per annum with free furnished quarters and generous allowances.—Full particulars of experience to BOX No. E5828, "The Engineer." A

MECHANICAL INTERMEDIATE DRAUGHTSMAN required to work on machine shop and special plant layouts, general pipework systems, and material handling equipment. Contributing pension scheme and other benefits.—Applications stating full particulars to Coniston Company, Eagle House, High Street, Wimbledon, S.W.19. E5861 A

PLANT ENGINEERS

An International Tyre Company soon to open a new factory in the Middle East requires a CHIEF PLANT ENGINEER and an ASSISTANT PLANT ENGINEER. The Plant Engineer will be responsible for all maintenance of machinery and buildings, for plant protection, and for the generation and distribution of all service utilities. Applicants should be qualified mechanical or electrical engineers with practical experience of plant operation preferably in the rubber industry. Starting salary will be substantial with cost of living and other local allowances. The initial contract would be for 3 years followed by 3 months home leave. It is expected that further 3 year contracts would follow and there would be opportunities for promotion to Company factories elsewhere. Free transportation to and from the territory would be provided for family at the start and finish of each contract. The successful candidates would become members of the Company's Pension Scheme.—BOX No. E5892, "The Engineer." A

PROJECT ENGINEER

A vacancy exists for an Engineer to join a small team engaged on project work in connection with improvements and new processes in the seamless steel tube industry.

The work is interesting and varied and may cover all aspects of a project from initial feasibility trials to the design, installation and commissioning of the final production unit.

The nature of the work is such that absolutely similar experience cannot be expected from candidates, and preference will therefore be given to a man who can demonstrate the qualities of versatility and energy, as well as qualifications up to degree standard in mechanical or electrical engineering.

Applications, from men in the age group 28-32, should be addressed to the Works Director, Tubes Limited, Kirby Muxloe, Nr. Leicester, giving brief personal history to date and salary expected. E5887 A

SENIOR CIVIL AND STRUCTURAL ENGINEER required by small Consulting Engineers. Must have had not less than ten years practical experience and not to be over 38 years old. Some design experience with Specialist reinforced concrete designing Company preferred and also Consulting Engineers engaged on buildings, factories, industrial plant essential. Experience of steelwork and marine work would be an asset. Extremely good prospects of promotion to a highly responsible capacity with full responsibility for running drawing office staff.—BOX No. E5872, "The Engineer." A

STRUCTURAL STEEL DESIGNER, minimum age 23, required by Structural Engineers in West London district.—Full particulars to C. & S. Construction Co., Ltd., Worton Road, Isleworth. Ref. C.D. E5905 A

THREE DETAIL DRAUGHTSMEN required in Consulting Engineers office for reinforced concrete work and structural work in the Birmingham area. Top grade salaries will be paid to the appointed men. Five-day week. Pension Scheme.—Apply in the first instance by letter, stating age, qualifications and salary required.—BOX No. E5867, "The Engineer." A

TECHNICAL ASSISTANT REQUIRED by established Rotary Compressor Manufacturers. D.O. experience essential. Good salary to engineer with right technical background.—Apply Tech. Manager, the B.A. Holland Engineering Co. Ltd., Lindo Lodge, Chesham, Bucks. E2990 A

THE BURMAH OIL COMPANY (PIPE LINES) LIMITED

require a

QUALIFIED ENGINEER

for service in NORTH EAST INDIA on the installation, operation and maintenance of a major crude oil pipeline.

The ideal candidate will be an engineer with either a mechanical and/or an electrical qualification and with experience of mechanical and electrical and preferably telecommunications work in connection with the installation, operation and maintenance of oil pipe installations.

This is a senior appointment involving the co-ordination of the work of Mechanical, Electrical and Telecommunications personnel engaged, in the first instance on the installation of large diesel pumping units, together with all ancillary equipment, including diesel driven generator sets, &c., which are to be telemetered and telecontrolled over a V.H.F. radio link and subsequently on the initial operation and maintenance of the pipeline system.

The appointment will initially be for two to two and a half years and is required to be filled as early as possible.

Salary will be on a Rupee basis, free of Indian taxation and not less than the equivalent of £2700 per annum. Messing and accommodation in India will be provided free.

Preferred age range 35 to 45 years, but a suitably qualified and active candidate might be considered above this range.

Applications should be addressed to the Company at Britannic House, Finsbury Circus, E.C.2, giving full details of qualifications, experience and personal particulars.

E5894 A

SITUATIONS VACANT

Mullard

MULLARD SOUTHAMPTON WORKS

have a vacancy for a

GRADUATE ENGINEER

to join their rapidly expanding Plant Department. The department provides a very wide variety of mechanical and electrical services to an establishment concerned with Research, Development and Quantity Production of Transistors, and the post calls for a man capable of progressing to a senior appointment. A post-graduate apprenticeship or sound practical experience are therefore essential.

The position offers an opportunity to a man with a good theoretical background to extend his practical knowledge of problems arising in an industry calling for the fullest range of these services; and offers possibilities of promotion within a large and expanding group of companies.

Please apply in writing to the

Plant Personnel Officer,
Mullard Southampton Works,
Millbrook Industrial Estate, Southampton,
quoting the reference C.18

"Mullard" is the Trade Mark of Mullard Limited. E5851 A

INDUSTRIAL CONSULTANTS OR ENGINEERS

with considerable experience in production planning, work study, and production control and who are university graduates, are invited to apply for a position on the senior production staff of a well-known company with factories located in England, Scotland, Wales and abroad. This is a high-level appointment and will carry a salary from £1500 to £2500 depending upon experience. There will be opportunities for advancement to top-level managerial positions within a few years. Age limits 25 to 37. There is a good pension scheme. All applications will be treated in strict confidence, and should state age, qualifications and experience.—BOX No. E5888, "The Engineer."

A

Applications are invited for two appointments with an old-established Company in the South of England engaged in the manufacture of medium-to-high-pressure equipment for Main and Industrial Power Stations, Naval and Merchant Marine, Oil and Chemical Process Plants and Nuclear applications.

(1) Manufacturing Manager:

The Manager would be responsible for all phases of Works production, including overall administration, organisation and production planning of a Works carrying out all conventional Works processes including the fabrication in a variety of materials of medium-to-high-pressure vessels. He would have, as his senior officers, a Works Manager, Works Superintendent and Quality Control and Inspection Engineer. He would be directly responsible to the Company's Divisional Managers and Directors and must be capable of operating at that level.
Salary would be in accordance with qualifications and experience but would not be less than £2,000 p.a.

(2) Quality Control Engineer:

The Engineer would be responsible for the maintenance of quality control of all the Works products and for all inspection both during and on completion of manufacture. He would have to have experience with welding techniques on materials including stainless, alloy and carbon steels and non-ferrous metals together with a thorough knowledge of all branches of non-destructive testing. A fully equipped metallurgical and chemical laboratory is available.
The Engineer would be directly responsible to the Company's Divisional Managers and Directors and must be capable of operating at that level.
Salary will be in accordance with qualifications and experience but would not be less than £1,500 p.a.

For both positions applicants must have good academic qualifications, first-class practical experience of the type of work involved and must have held positions of responsibility in connection therewith.

Applications, which will be treated in strict confidence, should include full particulars of age, qualifications, past experience and previous posts held, and should state when, if appointed, they would be in a position to take up the new appointments. A Contributory pension scheme is in operation.

Applications to be addressed to Personnel Manager, BOX No. E5896, "The Engineer."

A

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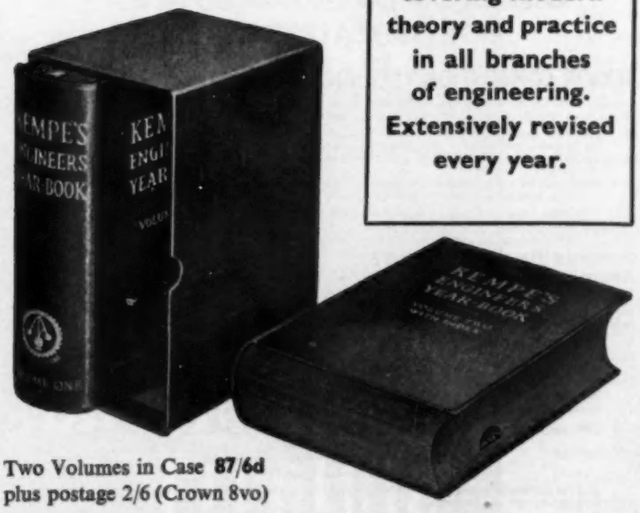
3,000 pages, 79 chapters covering modern theory and practice in all branches of engineering. Extensively revised every year.



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SITUATIONS VACANT

PRODUCTION CONTROLLER

for

KENDALL & GENT LIMITED
(Associated with W. E. Sykes Limited)

A well-qualified man experienced in modern methods for production control in engineering, preferably in medium to heavy machine tool manufacture, is required to organise and control the work programming and shop loading, material control, tool and other storekeeping and progressing functions of the factory.

The appointment will provide a good salary, valuable pension rights and scope for progress within this group of manufacturers of machine tools of high repute.

Write, in confidence, with full details of qualifications, past and present employment, age and all other relevant details to **The Secretary, Kendall & Gent Limited, Victoria Works, Gorton, Manchester 18.**

E5873 A

MSL *have been retained to advise on the appointment of a*

CHIEF ENGINEER
Paper Industry

for a company employing 1000 on paper manufacture and conversion. He will be responsible to the Managing Director for a staff of over 100 including drawing office and mechanical, electrical, power and transport engineers engaged in process and maintenance work. In addition he will be required to assist in planning and carrying out a development scheme of considerable scale. Part of his duties will be to establish planned maintenance and engineering stock control.

Candidates must be professional engineers with experience of managing engineering staff in the paper industry. It is intended to operate much of the new plant by instrumentation and remote control, and experience in this field would be useful. Experience of working to budget is desirable. Preferred age 35 to 45 years. Initial salary £2,000 to £2,500 with pension and life assurance. Removal expenses paid. Assistance with housing. Please send brief details in confidence quoting reference G.2433 to D. C. Duncan.

MANAGEMENT SELECTION LIMITED
17, Stratton Street, London, W.1.

In no circumstances will a candidate's identity be disclosed to our client unless he gives permission after a confidential interview at which he will be given full details of the appointment.

E5911 A

Research Design & Development in Steel

As a part of the planned growth of the Steel Company of Wales Limited, Steel Division, the following Mechanical Engineering appointments are being created.

Men of high calibre who consider they might be interested in these appointments are invited to write to us. The majority of applicants will be interviewed and many will visit the plant where they can judge for themselves the success of the Company and the facilities for their families living in the district.

Senior Research Engineer
To initiate and co-ordinate research and design investigations into mechanical engineering problems encountered in the operations and future development of the Company's Steel Division. A University Degree and experience of mechanical engineering research work, either in the industry or in the manufacture of steelworks or similar plant, are required.

Research Engineer
To investigate fundamental and applied mechanical engineering problems associated with the production of Iron and Steel and to establish basic design data for future developments of the Company.

New Work Engineer
To lead the Design and Development work for the Hot and Cold Rolling Mills in the Company's Steel Division. These include a 45in. Universal Slabbing Mill, 80in Hot Strip Mill, 80in. and 56in. Cold Reduction Mills and all associated plant and furnaces.

Corporate membership of the Institution of Mechanical Engineers and experience in the design or operation of Rolling Mills and associated plant is required.

Assistant New Work Engineer
To work on Mechanical Engineering, design and developments associated with the Open Hearth Shops, Bessemer Shop and Continuous Casting Plant in the Company's Steel Division.

A University Degree or alternative suitable qualifications as a mechanical engineer, and preferably experience of the design of steelmaking equipment will be an advantage.

Please write to:— **Superintendent, Personnel Services,**
THE STEEL COMPANY OF WALES LIMITED,
(Steel Division), Abbey Works, Port Talbot, Glam.

E5880 A

Classified Advts. continued on page 132

SITUATIONS VACANT

THE POWER PLANT COMPANY LTD.,
West Drayton, Middlesex

Require a **MECHANICAL ENGINEERING DRAUGHTSMAN,** Higher National level, experience in Heavy Engineering and Gearing an advantage. Pension Scheme, Canteen and Social facilities.

Write to Chief Draughtsman stating age, experience and salary required.

E5859 A

SITUATIONS VACANT

SENIOR MECHANICAL DRAUGHTSMAN

Large company in South Bucks requires a senior draughtsman of H.N.C. standard for expanding development department. The work will comprise arrangement of process equipment and conveyors, design of the necessary supporting steelwork, and process and utility pipe lay-outs. Some knowledge of electrical work would be useful. Preferred age range 25-35. This is an interesting position with good prospects for a man prepared to use his initiative and who is capable of sound thinking and hard work.

Applications should contain full details of training and positions held and be sent to Box No. 2995, " The Engineer."

A

PILKINGTONS

MECHANICAL ENGINEERS

If you have a good honours degree in Mechanical Engineering and would like to hold a responsible job in an expanding industry, you are invited to write about yourself to Dr. J. B. Higham, Head of Technical Development, Pilkington Brothers Limited, St. Helens, Lancashire.

You would be required to lead a team working on projects for mechanising the handling and cutting of plate and Float glass in conjunction with the production departments.

The greatest name in the world of GLASS

E5854 A

DESIGNER-DRAUGHTSMEN

The continuous development of our Design consultancy service provides opportunities for men with Higher National Certificates, and with a good design background preferably in special purpose machinery. Applicants should be willing to travel and be capable of maintaining effective contact with senior executives in all branches of industry. Duties will include the control of detailers.

DRAUGHTSMEN

Several vacancies also exist for draughtsmen who wish to progress in a position that offers interesting and varied work. The draughtsmen selected will mainly provide detailing capacity, with some opportunities for design experience on special purpose machinery and all branches of mechanical engineering. Successful applicants will receive training, which will include visits to Exhibitions.

These progressive appointments carry attractive salaries, above national rates, which are reviewed annually. Superannuation scheme. Removal expenses paid. Send details to the Secretary (I.732), Production Engineering Research Association, Melton Mowbray, Leics.

E5865 A

CENTRAL ELECTRICITY GENERATING BOARD

SENIOR ASSISTANT ENGINEER (CIVIL)

required in the CIVIL ENGINEERING SUB-BRANCH of the TRANSMISSION CONSTRUCTION BRANCH, TRANSMISSION DEPARTMENT.

The appointment will ultimately be at the Board's office at Guildford but initially, the successful applicant will be required to work for a few months at Headquarters, London, S.E.1.

Candidates must be Corporate Members of one of the recognised Engineering Institutions and/or hold an appropriate University Degree.

The Civil Engineering Sub-Branch carries out the design and construction by contract of civil engineering and building work required in connection with the establishment or extension of high voltage substations.

The successful applicant would be required to take charge of the Design and Special Duties Section of the Civil Engineering Sub-Branch. Candidates should possess a general knowledge of all branches of civil and structural engineering with particular emphasis on prestressed and reinforced concrete, structural steelwork, soil mechanics and foundations, and should also be proficient in advanced techniques of structural analysis and design.

- **Salary within the range £1,850—£2,395 p.a. plus London Allowance of £60 while applicable.**

Applications stating age, qualifications, experience, present position and salary, to the Personnel Officer, 24/30, Holborn, London, E.C.1., by 21st September. Envelopes should be marked " Confidential Ref ENR/320."

E5844 A

CENTRAL ELECTRICITY GENERATING BOARD
Southern, South Western and South Wales Region

RESEARCH AND DEVELOPMENT DEPARTMENT
PORTISHEAD, BRISTOL

SENIOR COMBUSTION TECHNOLOGIST - *REGIONAL VACANCY No. 79*

Applications are invited for the above post at new laboratories which have recently been set up at Portishead, which is ten miles south-west of Bristol.

The work involves the development of combustion systems in generating stations throughout the Region, particularly with respect to pulverised low volatile coals and heavy fuel oil. Current problems include the design of new types of burners but other problems await investigation.

There will be some freedom of choice in the subjects of investigation and a wide freedom of choice in methods of approach.

The successful candidate will be responsible for a team of research workers.

Applicants should be highly qualified and several years' experience of practical combustion systems is essential. Experience with either pulverised fuel or oil would be desirable. An ability to apply fundamental ideas to new designs is necessary.

Salary within the range £1,695 to £2,085, but exceptionally a salary up to £2,235 would be paid.

COMBUSTION SCIENTISTS & TECHNOLOGISTS (5 *posts*) *REGIONAL VACANCY No. 80*

Men with high academic qualifications but limited combustion experience are invited to apply for posts as *Combustion Scientists.* Men with considerable experience in the development or design of combustion systems including fuel feed systems, and suitably qualified, are invited to apply for posts as *Combustion Technologists.* The work will be on individual aspects of the above problems and for two posts this will involve being outstationed at Swansea, South Wales, in the first instance.

The salaries for these posts will be within the ranges:-

£1095 to £1720 (Grades 9 to 5) — 3 posts
£1005 to £1410 (Grades 9 to 8) — 1 post
£730 to £1245 (Grades 13 to 10) — 1 post

and the successful applicants will be placed in the scales according to experience, qualifications, and the nature of the work.

For all the posts there is a contributory pension scheme and opportunity for promotion within the Board's Research and Development Departments. Assistance may, under certain conditions, be given with housing.

Applications on Form AE6/ACT obtainable from the Regional Secretary,
CENTRAL ELECTRICITY GENERATING BOARD,
Southern, South Western and South Wales Region,
1, Eaton Crescent, Clifton, Bristol 8,
should be returned to him together with any other appropriate information, by not later than Monday, 26th September, 1960.

E5879 A

SITUATIONS VACANT

RTB

RICHARD THOMAS & BALDWINS LIMITED

have vacancies for

CONTROL ENGINEERS *(MECHANICAL)*

at the Spencer Works, Llanwern, near Newport, Mon.

Candidates should be fully-qualified engineers with wide general experience of some aspect of steelworks practice. Successful candidates will be responsible for the preparation of detailed programmes covering all stages of construction, including civil works, plant erection, and commissioning.

They will also be responsible for programming erection on site and progressing of outstanding items through the works of the various plant manufacturers.

These appointments offer a unique opportunity of gaining experience in the planning and control aspects of a large-scale construction project. The appointments are permanent, and should lead to engineering posts in the future maintenance or development departments of the Spencer Works

Application forms, which should be returned by September 26, 1960, can be obtained from

The Manager
Staff & Labour Relations Department,
Spencer Works, Llanwern,
Nr. Newport, Mon.

Please quote 200/4 on the original letter of application.

E5863 A

SITUATIONS VACANT

A PHYSICIST AND AN ENGINEER

are required by the United Kingdom Atomic Energy Authority (Production Group) at Windscale and Calder Works, Cumberland.

Both posts are in the Experimental and Technical Group which will form part of the Operations Team for the Advanced Gas Cooled Reactor. The Group will be directly concerned with the implementation of a large scale programme of experiments in the reactor and five experimental loops aimed at studying the performance of the reactor and reactor materials expecially fuel elements. These posts will present a unique opportunity to the type of man interested in the technical aspects of nuclear power station operation and experimental work.

PHYSICIST

Will be concerned with the examination of proposals for reactor experiments especially during commissioning to determine their feasibility and safety, and in the preparation and planning of the required experimental operating procedures. In addition he will be required to provide a routine technical service to the plant operating staff. An important feature of this work will be the consideration of the implications of experimental results on reactor operation and the proposal of operational investigations into overall plant performance and efficiency. Some experience in the reactor physics or heat transfer field will be an advantage. In addition the candidate must have an honours degree, or equivalent, in physics and has at least three years relevant industrial or research experience.

ENGINEER

Will be expected to examine proposals for all reactors and loop experiments, consider this feasibility and safety, and prepare detailed operating instructions and programmes. This will involve the checking and testing of the experimental components and technical consideration of their performance. In addition he will be required to assist in the preparation of loop plant item and process operating instructions. Candidates should preferably have had some experience of mechanical or electrical design and must be a corporate member of an appropriate professional institution and have served a recognised engineering apprenticeship, or have an honours degree, or equivalent qualification and have had at least three years relevant industrial or research experience.

Salary within the scale £1370 to £1825 p.a. according to qualifications and experience. Contributory Superannuation. Staff Housing Scheme.

Send postcard for application form quoting reference (P/W.51/J1), to Recruitment Officer, U.K.A.E.A., (Production Group), Windscale Works, Sellafield, Seascale, Cumberland.

Closing date: 3rd October, 1960. E5881 A

SITUATIONS VACANT

DRAUGHTSMEN

Draughtsmen are required at the Midlands Research Station, Solihull.

The duties are interesting and will include work on the design of pilot and prototype plant associated with the development of new high-pressure processes for the production of town gas.

Candidates should possess at least an O.N.C. certificate in Mechanical Engineering.

The salary for the appointments, which are pensionable and subject to medical examination will be within the range of £770-£1015 per annum.

Applications, stating age, education and experience, should be addressed to the Industrial Relations Officer,

WEST MIDLANDS GAS BOARD,
6, Augustus Road, Edgbaston, Birmingham, 15

E190 A

SITUATIONS VACANT

APPLEBY-FRODINGHAM STEEL COMPANY, SCUNTHORPE, LINCOLNSHIRE,

invite applications for a

SENIOR DESIGNER

with experience of heavy PLATE AND SECTION ROLLING MILLS PLANT.

Permanent situation with interesting and varied work.

Apply, giving age, full particulars of experience, &c., to The Chief Engineer.

E5804 A

POWER RECTIFIER DESIGN

Due to expanding business, a large electrical manufacturing firm in the Midlands requires assistant Design Engineers and Technical Assistants, for power rectifier work. Previous rectifier experience not necessary, but applicants should have degree (electrical), or HNC, or respective equivalents, and some practical training. Work involves mercury arc and semi-conductor rectifiers, and application engineering of all kinds, with scope for wide experience and interest; good salary and prospects. Pleasant residential area; ample housing; excellent educational facilities.

Apply with full particulars to BOX No. E5518, "The Engineer."

A

RESEARCH IN INDUSTRY

'ENGLISH ELECTRIC'

MECHANICAL ENGINEERING LABORATORIES

Men who wish to engage in research in the personal and intimate way that is typical of the Universities may not realise that industry can offer excellent opportunities for work of this kind at the same time as it can afford them the stimulus of ready access to practising engineers.

The Mechanical Engineering Laboratories of the English Electric Company at Whetstone, near Leicester, are devoted to the study of fundamental projects related to the Company's virtually unlimited interests in Mechanical Engineering. It works through small teams so as to give the freest possible rein to personal enthusiasms and talent, and it aims to put itself in the forefront of all new thinking on topics coming within its sphere of interest.

Although an exciting range of researches already exists in the fields of strength of materials, structures, vibrations, fluid mechanics, controls, heat transfer, thermodynamics, lubrication, friction and wear and mathematics, the staff is given every encouragement to help in establishing future programmes on new lines.

The Company wishes to foster this work and to do this it invites the participation at various levels of a number of men with initiative and suitable academic training. Previous industrial experience is unimportant but an aptitude for clear thinking and original work is essential. The Laboratories would be delighted to hear from graduates to whom this prospect appeals. Correspondence should be addressed to The Head of the Mechanical Engineering Laboratories, c/o Dept. G.P.S., English Electric House, Strand, London, W.C.2, quoting reference E1916D.

E5850 A

Classified Advts. continued on page 134

SITUATIONS VACANT

THE UNITED KINGDOM ATOMIC ENERGY AUTHORITY

require

ENGINEERING AND EXPERIMENTAL STAFF

for posts of interest and opportunity concerned with

DESIGN AND DEVELOPMENT PROBLEMS, ENVIRONMENTAL TESTING

and

APPLICATION OF MATHEMATICAL ANALYSIS

Selected applicants will join a team of Engineers employing exceptionally well-equipped facilities in a modern establishment and deal with the practical and theoretical solutions of problems referred to them by design staff.

Candidates should possess appropriate minimum qualifications (e.g. Pass Degree, H.N.C.) and experience in the field of Electrical or Mechanical Engineering or Mathematics For the senior posts, Corporate Membership of a Senior Engineering Institution is necessary and an Honours Degree would be an advantage.

SALARY : To be assessed in relation to age, qualifications and experience, within the range £605 — £1,900 p.a.

SUPERANNUATION SCHEME. HOUSING, HOUSE PURCHASE AND HOSTEL FACILITIES. FIVE-DAY WEEK.

For application form send postcard (or letter) to the Senior Recruitment Officer, A.W.R.E., Aldermaston, Berks., quoting ref. 2779/25. E5852 A

BRITISH OXYGEN GASES LTD.

SENIOR FUEL ENGINEER

British Oxygen Gases Ltd. have a vacancy for a Senior Fuel Engineer at their Sales Technical Service Department, situated at Cricklewood. This is a senior appointment and the successful applicant will be responsible for handling all technical problems connected with the use of propane and butane. He will act as a technical advisor to a Sales Force operating in the field and should therefore have had a number of years' experience in the application and handling of these gases. There are excellent prospects and an attractive commencing salary will be paid. Housing assistance available if required.

Write, stating full details to Personnel Manager,

British Oxygen Gases Ltd.,

Spencer House, St. James' Place, London, S.W.1.

E5878 A

SITUATIONS WANTED

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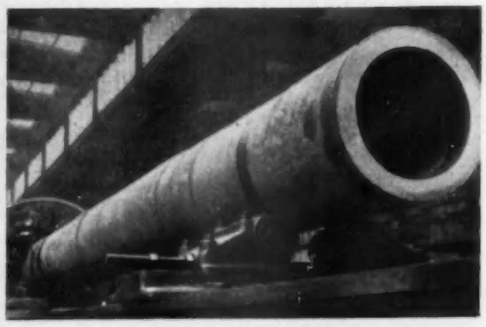

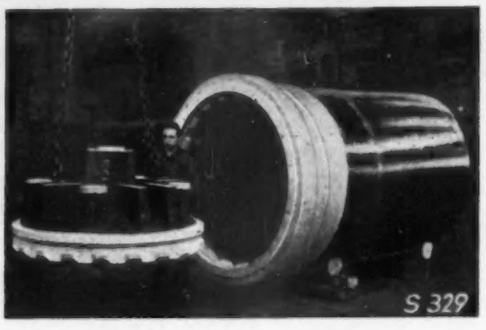

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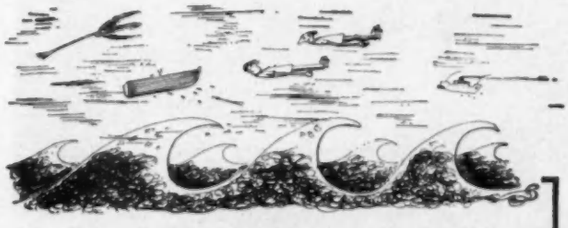

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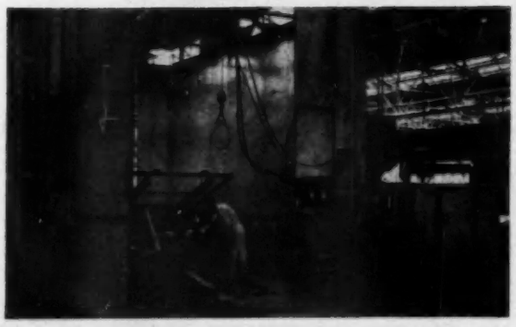

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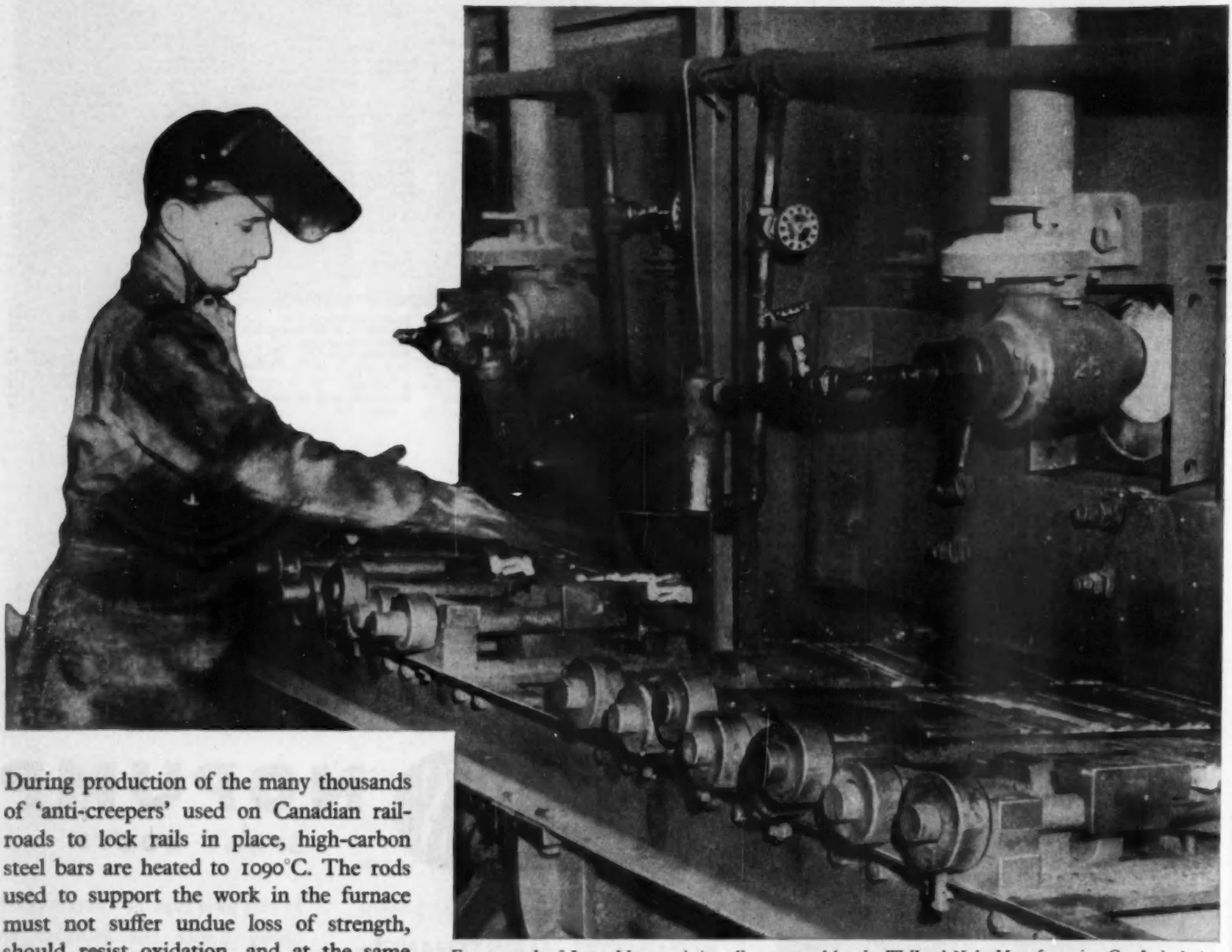

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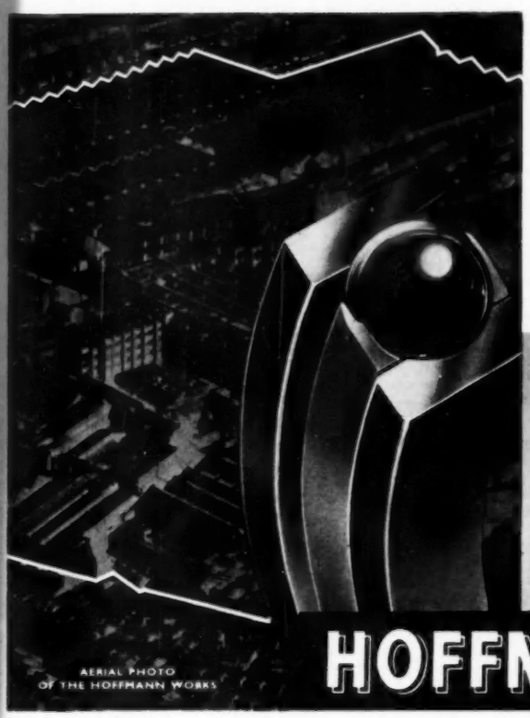

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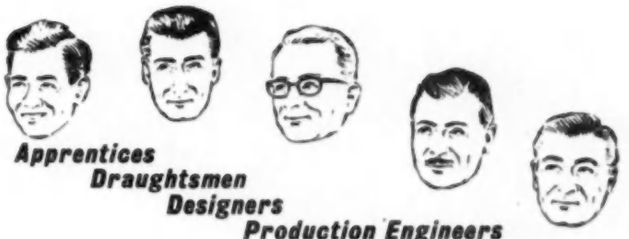

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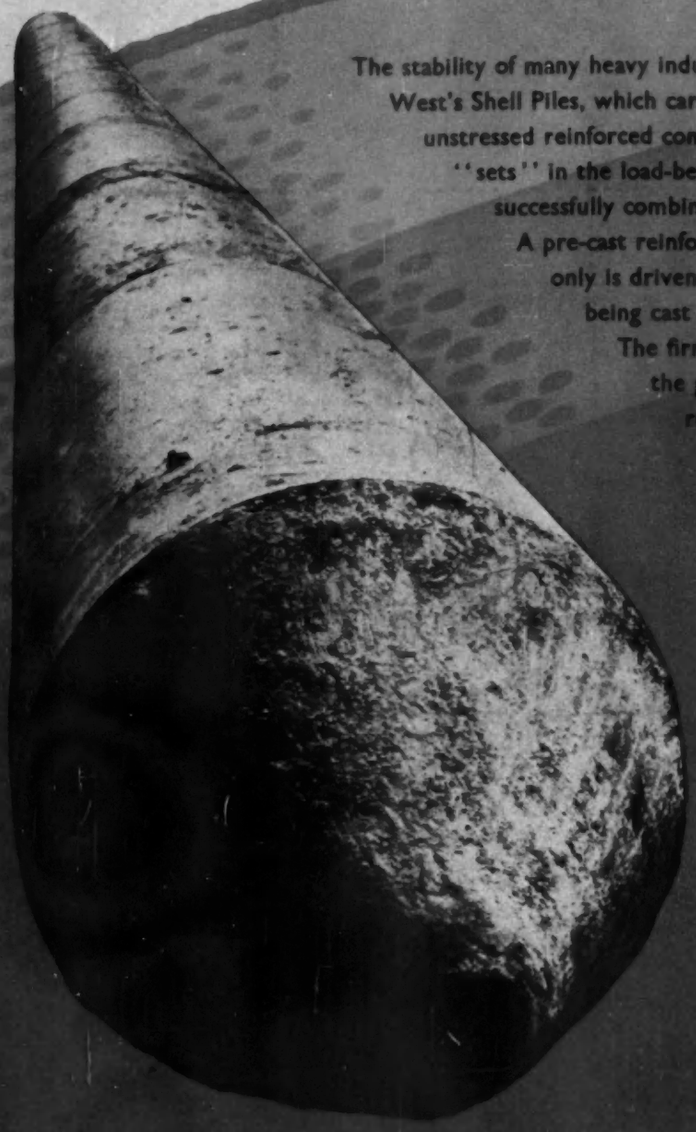

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